NON-IRRIGATION CONSUMPTIVE DEMAND PROJECTIONS LITTLE BOW PROJECT EIA

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Alberta
ENVIRONMENT

Natural Resources Service
Bow Region

Worldwide Resource Economics

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July 30, 1999

File: 371

Mr. Bob Morrison, Planner
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Natural Resources Service - Bow Region
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Calgary, Alberta, T3H 1H5

Dear Mr. Morrison:

SUBJECT: **Non-Irrigation Consumptive Demand Projections - Little Bow Project EIA**

We are pleased to submit the final report on the above-captioned project. This version incorporates changes made in response to comments received on the draft report from yourself and officials in the ten municipal jurisdictions and the Eden Valley First Nation which lie within the study area.

You will note in Appendix B that many individuals contributed ideas and data during the preparation of this study. We appreciate all of this assistance and in particular the extensive cooperation provided by you and your colleagues at Alberta Environment and by officials within the various jurisdictions.

We have enjoyed working on this assignment and trust that it will serve to advance future water management and planning in the Highwood /Little Bow River basins. We remain available to assist you as required in review and consultation for the Little Bow Project.

Yours truly,

HYDROCONSULT EN3 Services Ltd.

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1 acre-foot = 1.233 dam^3	1 dam^3 = 0.811 acre-feet
1 acre-foot = 271,470 imperial gallons	1 dam^3 = 220,162 imperial gallons

EXECUTIVE SUMMARY

Purpose

The Panel[1] that reviewed the environmental impact assessment (EIA) for the Little Bow Project decided that the proposed Highwood Diversion Plan is not sustainable. Among other things, the Panel concluded that the proposed Diversion Plan does not adequately meet future needs for consumptive use of water.

Future demand for irrigation in the Highwood and Little Bow River Basins has been extensively analyzed,[2] but future demand for other consumptive uses has not. This report has been prepared to fill that information gap.

Scope

This report contains forecasts of water withdrawal and consumptive use for the Highwood River, Sheep River, upper Little Bow River, and Mosquito Creek basins. Using 1996 as a baseline, projections were made to the years 2021 and 2046. Three scenarios (low, medium, and high) were developed to reflect the probable range of growth.

Methodology

Preparation of these forecasts relied on existing data, predictions, and expert opinion on population and economic development. Interviews were conducted with representatives of the ten municipalities and one First Nation in the study area. A draft of this report was made available for review by the people interviewed to ensure the accuracy of the information.

The time period used for these forecasts extends quite far into the future. As a result, a number of assumptions were required to fill in gaps or extend available data as necessary. These assumptions are documented throughout the report.

Summary of Results

By the middle of the next century, the population in the Highwood -Upper Little Bow basins is expected to grow from 35,620 to somewhere between 85,000 and 100,000 (Table ES-1). Demand for non-irrigation water withdrawals should be in the range of 35,000 to 48,000 cubic decametres (dam^3), an increase of 91% to 160% over the present. Non-irrigation consumptive use is expected to increase to between 19,000 and 25,000 dam^3, for an increase of 75% to 131% over the present.

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1 The Review Panel was composed of representatives from Alberta's Natural Resources Conservation Board and the Canadian Environmental Assessment Agency.

2 See Alberta Environment, *Irrigation Expansion Guidelines* (c. 1990) and Alberta Environment, *Landholder Survey: Highwood and Sheep Rivers*, 1992.

Table ES-1
SUMMARY OF STUDY AREA PROJECTIONS WITH SENSITIVITIES

Category	Year				
	Current (1996)	2021		2046	
		Projection	Low - High Range	Projection	Low – High Range
Population	35,620	58,930	56,400 - 61,560	92,840	85,300 – 101,000
Withdrawal (dam^3)	18,510	28,090	25,490 – 31,260	40,810	35,430 – 48,150
Consumptive Use (dam^3)	10,780	15,450	14,130 – 16,990	21,500	18,820 – 24,930
Return Flow (dam^3)	7,730	12,640	11,360 – 14,270	19,310	16,610 – 23,220

Return Flow = Withdrawal – Consumptive Use 1 dam^3 = 1000 m^3 = 0.811 acre-ft.

The greatest increases in population and water demand are expected in the Sheep River sub-basin. Population in the Sheep sub-basin is likely to triple in the next fifty years. Demand for non-irrigation withdrawals in the Sheep sub-basin is expected to be over two and one-half (260%) times the present demand.

Industrial use will show the greatest growth in water demand, increasing from 26% of current total demand to approximately 34% of demand by mid-century (Table ES-2). The proportion of water used for stockwatering is expected to decline in the future since stockwatering demands are already well-established in the study area.

Table ES-2
STUDY AREA DISTRIBUTION OF NON-IRRIGATION WATER DEMANDS
(as a percent of total)

WITHDRAWALS			
Use Category	Current (1996)	Yr. 2021	Yr. 2046
Municipal	39.2%	38.9%	40.3%
Industrial	26.2%	31.3%	34.3%
Stockwatering	23.2%	18.0%	13.6%
Other Agricultural	6.0%	5.8%	5.2%
Rural Domestic	5.5%	6.0%	6.6%

CONSUMPTIVE USE			
Use Category	Current (1996)	Yr. 2021	Yr. 2046
Municipal	22%	22%	23%
Industrial	23.2%	28.9%	33.5%
Stockwatering	40.2%	32.8%	25.9%
Other Agricultural	5.2%	5.3%	4.9%
Rural Domestic	9.5%	10.9%	12.5%

1.0 INTRODUCTION

1.1 Background

Hydroconsult, in association with Worldwide Resource Economics, was contracted by Alberta Environment (AENV) to develop projections for population, water withdrawal and consumptive demand for non-irrigation uses in the Highwood River Basin (including the Sheep River) and the Upper Little Bow River Basin upstream of the proposed Little Bow River Reservoir (including Mosquito Creek). The study area and four sub-basins are shown in Figure 1.

Water uses were to be broken down into non-irrigation agriculture, municipal, industrial and domestic.

The Terms of Reference (Appendix A) specified a base year – the consultants selected 1996 – and corresponding years 25 and 50 years in the future (i.e., 2021 and 2046).

Projections were to cover the four non-irrigation water uses for the four river basins for three reference years. Emphasis was to be placed on water volumes, with characterizations of water quality being added as the data permitted.

Special attention was to be given to the eleven municipal jurisdictions that lie, wholly or partially, within the study area. These include:

- two municipal districts (M.D. of Foothills No. 31 and M.D. of Willow Creek No. 26)
- one county (County of Vulcan No. 2)
- six towns (Black Diamond, High River, Nanton, Okotoks, Turner Valley and Vulcan)
- one village (Longview) and
- Eden Valley First Nation (I.R. 216)

The Town of Vulcan, lying outside the boundaries of the study area, was included in the this list because it relies on piped water from the Upper Little Bow River for the supply of its water treatment and distribution system.

1.2 Basis

The study involved the collection and review of data from a variety of sources including:

- relevant documents as encountered, in particular:
  - "Population and Economic Outlook for the Bow River Basin – Bow Basin Plan," prepared for Environmental Service – Prairie Region, Alberta Environmental Protection by Multiplan Solutions, March 1998;
  - "Consumptive Demand Analysis – Highwood River Diversion Plan," prepared by Water Resources Management Services, Planning Division, Southern Region, Alberta Environmental Protection, March 1993; and
  - a cursory review of earlier watershed management studies that cover the study area, such as those of the South Saskatchewan River Basin Planning Program.
- master lists of licence files and selected files made available by AENV Water Administration Branch offices in Calgary for the northern portion of the study area (i.e. within Bow Region) and Lethbridge for the southern portion of the study area (i.e. within Prairie Region);
- permit files from the Municipal Approvals Group/Water and Wastewater identifying treatment plant inflows/outflows and effluent quality;
- historical data files on water withdrawals, consumption and return flows that had been compiled by AENV for the Highwood Instream Flow Needs Study and the Little Bow Project EIA up to 1988;
- summary lists of outstanding water licence applications to assess the nature of some of the new licences which might receive approval in the future;
- interviews with AENV officials to understand more fully the nature of the files consulted and to address the limitations of the data being reviewed and the significance of missing/unavailable data;
- interviews with officials in each of the 11 municipal jurisdictions named in the Terms of Reference to address: (a) historical water use; (b) population; (c) economic activity; and (d) projected water use; and

- interviews with officials in government departments other than AENV and other bodies including: Statistics Canada, Prairie Farm Rehabilitation Administration, Alberta Agriculture, Food and Rural Development, Alberta Economic Development, Alberta Transportation and Utilities, Alberta Treasury Statistics Branch, Headwaters Health Authority (Alberta Health), the City of Calgary Finance Department, the Population Research Laboratory of the University of Alberta and Ducks Unlimited.

1.3 Definitions and Assumptions

The base year for population calculations, 1996, was selected because it is a year for which population census material is available from Statistics Canada. The years 2021 and 2046 were chosen simply as the years corresponding to 25 and 50 years from that date into the future. The base year for analysis of licenced water withdrawals and estimated consumption, is noted in the report as "current" but in reality it represents recent average consumption (for example, with municipal water consumption an average was taken for the years 1994-98).

As will be seen in Section 4, none of the agencies that have produced recent population projections for the study area have attempted forecasts beyond 2016. The population projections for the study area featured here, i.e. 25 and 50 years out into the future, are well beyond the limits of what is considered by most professional demographers and economists as a manageable forecasting period. Accordingly, the following approach has been applied:

- give priority to existing near- and medium-term projections supported by previous forecasts;

- calculate an average growth rate for a portion of the earlier period for estimating in "straight line" fashion out into the distant future; and

- provide sensitivities for low growth and a high growth case assumptions.

Not all of the municipal districts (M.D. of Foothills No. 31 and M.D. of Willow Creek No. 26) and the County of Vulcan No. 2 lie within the subject watersheds. Population figures were adjusted to the study area boundaries by simply multiplying the total population by the fraction of the municipality's area encompassed within the study area. This meant focusing on 83.8% of the population of M.D. No. 31, 15.5% of the population of M.D. No. 26 and 5% of the population of County No. 2. The municipal district and county population figures exclude the six towns and one village in the study area which are tabulated separately.

Throughout the study, water withdrawals were taken to equal consumptive use plus return flows. In all cases, losses, due to factors such as evaporation and seepage, were treated as a component of consumptive use. For simplicity, metric units of measurement were utilized in all water-related tabulations. Conversion rates for acre-feet and imperial gallons are given at the end of the Table of Contents.

As per the Terms of Reference, a hydraulic connection is assumed between surface and ground water. In other words, this study did not distinguish between alternative types of water source – the focus was on relating demand to the four watersheds and major use categories whether supply was satisfied from mainstream surface flows, tributaries or groundwater.

Comments on future options for water supply arose in the interviews with officials in many municipalities. Although this subject matter is outside the Terms of Reference, it is convenient to mention them as follows:

- a request from Eden Valley First Nation that a treated water supply be made available for the approximately 100 households on the reserve (none are currently reached by the small water treatment system that serves four institutional buildings);

- an indication from M.D. No. 31 that its water supply agreement with the Town of High River will have to be extended and expanded to meet growing demands, especially in the Aldersyde/High River industrial area; and

- a suggestion from the Town of High River that in the long-term future it may be necessary to consider a water pipeline from the Bow River to augment local groundwater resources.

These comments will be forwarded to AENV's Bow Regional Board of Directors.

As is widely known, the Town of Okotoks has determined that it will plan for – and limit itself – to a population (approx. 30,000) that can be sustained by the Town's current and projected well fields and the capacity of its wastewater treatment plant.

Water quality analysis was limited to a cursory assessment of the quality of water effluent discharged from municipal wastewater treatment plants, and some comments on likely trends in water quality over the long-term. The capacity of existing water treatment, storage (especially significant in Vulcan) and wastewater treatment infrastructure to cope with future growth was outside the terms of reference for this study.

2.0 CURRENT POPULATION AND ECONOMIC ACTIVITY

2.1 Historical Population

Census data on the total population of each of the Census Sub-Divisions in the study area were obtained from Statistics Canada for 1981, 1986, 1991 and 1996. There was a correspondence between Census Sub-Divisions and municipalities. As indicated in Section 1.3, adjustments were needed for M.D. No. 31, M.D. No. 26 and County No. 2 in order to match to the boundaries of the study area.

The population for the study area for 1981, 1986, 1991 and 1996 is shown in Table 1. The data have been compiled by municipality (or in the cases of M.D. No. 31, M.D. No, 26 and County No. 2, portions thereof) and by river basin. The total estimated population of the four basins in 1996 is 35,620.

Table 1 (refer to tab at end of report text for all Tables) indicates that growth rates have increased for all of the river basins in the study area since 1991. The data also show that growth rates fall off significantly with increasing distance from Calgary.

The Sheep River Basin, closest to Calgary, consistently had the largest portion of the study area's population and the highest growth rates over the 20-year period. The Sheep Basin population increased almost 24% in the five-year period between 1991 and 1996 – an annual rate of increase of about 4%. In fact, M.D. No. 31 and the Town of Okotoks are among the fastest growing municipalities in Canada.

Population growth in the Highwood Basin has also been strong, although less than the Sheep Basin. At the other extreme, the northern section of M.D. No. 26 and the western edge of County No. 2, both began the 20-year period with absolute population losses. These areas have recently begun to exhibit small but steady growth.

2.2 Characterization of Economic Activity

The study area has a varied mix of economic activity. It can be characterized briefly as follows:

<u>Sheep River Basin</u>
- heavily influenced by the growth of Calgary,
- many acreages and country residential,
- high percentage of employed population travelling to Calgary to work,
- significant growth of service sector to accommodate increased population,
- growth in number of recreational facilities such as golf courses, equestrian,
- some light industry,
- some livestock and, and
- some oil and gas.

Highwood River Basin
- somewhat influenced by the growth of Calgary,
- small percentage of employed population travelling to Calgary to work,
- some growth of service sector to accommodate increased population,
- some recreation facilities,
- some light industry (including movie production around Longview),
- a few significant industrial facilities,
- some livestock including feedlots, and
- some oil and gas.

Mosquito Creek Basin
- minimal influence from growth of Calgary,
- insignificant commuting to Calgary,
- some trade and service links to Lethbridge,
- heavy emphasis on livestock, and
- some oil and gas.

Little Bow River Basin
- minor influence from growth of Calgary,
- minimal percentage of employed population travelling to Calgary to work,
- some growth in service sector,
- some livestock, and
- some oil and gas.

The higher pace of development in Okotoks (in the Sheep River Basin) is evident from the tabulation of construction projects shown in Table 2.

The projects lying within the study area have been extracted from the lists prepared by Alberta Economic Development ("Inventory of Major Projects – December 1998" and "Inventory of Alberta Regional Projects – January 1999"). The list (which may not be entirely accurate in some of its details) shows that 15 out of the 22 projects have an Okotoks location. It also describes both public and private sector investments in a wide variety of sectors.

2.3 Livestock Inventories

Data were compiled on livestock numbers from the Statistics Canada Census of Agriculture of 1981, 1986, 1991 and 1996 for M.D. No. 31, M.D. No. 26 and County No. 2. The numbers presented in Table 3 are the totals for each municipality and have not been estimated for the study area.

The four species descriptors considered were "total cattle and calves," "total pigs," "total sheep and lambs" and "total hens and chickens." Due to seasonal fluctuations, livestock inventory numbers should ideally be based on the same calendar date each census year to be comparable. For 1981, 1986 and 1991, the data were collected on June 3 or 4, however the 1996 data (as an economy measure) were collected on May 14.

The livestock inventories in Table 3 suggest substantial growth (between 40 and 70%) in cattle and calves in each municipality between 1991 and 1996 – a reflection of the rapid intensification of beef cattle operations. Trends in numbers of pigs, sheep and lambs and poultry are not as evident from the data.

Clearly, the study area does encompass intensive operations in cattle, pigs and poultry, and it would appear that the size of such operations is increasing. However, according to the Prairie Farm Rehabilitation Administration (PFRA) and Alberta Agriculture, Food and Rural Development (AAFRD), there may currently be no more than 25 intensive livestock operations in the study area: about 10 in M.D. No. 31 (including three large ones), approximately 10-13 in the northern portion of M.D. No. 26 and two or three in the western boundary area of County No. 2.

This estimate does not include a number of beef cattle operations in the northern portion of M.D. No. 26 which carry out intensive feeding in the summer months when the cattle have been rounded up and brought in from the winter range.

3.0 CURRENT WATER USE

3.1 Municipal Water Withdrawals and Consumptive Use

Sources of information on actual municipal water use in the study area are limited to municipal and industrial records, specifically the water treatment plant and wastewater treatment plant reports submitted to AENV.

With the assistance of AENV staff, actual records were reviewed for withdrawal (also termed gross diversion), consumptive use (including losses) and return flow. The results are summarized in Table 4 for three separate time periods: an average for 1984-87 (data compiled for an earlier AENV study), a 1990-93 average and a 1994-98 average. In some instances, table entries were calculated on the basis of fewer years of data than indicated in the column header because of missing data.

In some instances, consumptive use estimates were determined from patterns based on a review of the actual data and from interviews. Judgment was especially appropriate in the cases of Nanton and Black Diamond where infiltration of groundwater (and storm water runoff) into the sewer system is appreciable (and where aging sewer lines are being replaced).

Not all of the effluent released by wastewater treatment plants is counted as return flow. In summer months, a portion of the effluent of the Town of Okotoks is used for golf course irrigation and Okotoks data were adjusted for this. However, some of High River's effluent is utilized by a nearby tree farm, and some of Cargill's effluent is used by ranchers to irrigate hay crops; these amounts vary substantially and are not taken into account.

The main return flow from the Town of High River and Cargill occurs via a pipeline to Frank Lake in the Little Bow basin. The Frank Lake stabilization project consists of the effluent from these wastewater plants plus a wetland licence by Ducks Unlimited to transfer up to 2466 dam^3 (2000 acre-ft) from the Highwood basin to Frank Lake to maintain the waterfowl habitat and the aesthetic value of the wetland. On average (1990 to 1997), the Town of High River discharged 1200 dam^3 per year and Cargill discharged 878 dam^3 per year to Frank Lake (Golder, 1999). Ducks Unlimited's water intake on the Highwood River is used to supplement these flows to Frank Lake but it is silted up and has not diverted any water since 1993. Withdrawals peaked at 1070 dam3 in 1992 and have averaged 286 dam^3 over the past nine years from 1990-1998. Ducks Unlimited plans to repair the intake for possible future use. The operating plan is to maintain optimum levels for waterfowl yet minimize spills from the lake with evaporation as the principal outlet.

For the purposes of this study, the Frank Lake stabilization project is treated separately and is assumed as a withdrawal of 286 dam^3 (1990-98 average) from the Highwood River plus the 1994-1998 average effluent flows from the wastewater plants for the base year (1996). No projections are made for future withdrawals and no limitations on industrial growth are assumed because of effluent quality restrictions (Studies are in progress by AENV and Ducks Unlimited [Golder, 1999] to review diversion rates, water quality and Frank Lake spill issues).

Depending upon the focus of a particular assessment or basin, the Frank Lake stabilization project might be considered as a withdrawal and consumptive use from the Highwood, as an inflow to the Little Bow or as a consumptive use (as a result of net evaporation) from the Little Bow. Detailed water balance studies (Golder, 1999), beyond the scope of this report, are required to quantify actual uses and potential lake spills.

Further complications which could not be reflected completely in the data were the practice of hauling municipally produced treated water by rural residents, and the piping of town water out to nearby water co-operatives and other users. The latter issue is reflected in Town of High River tabulations but it is not captured in data elsewhere (such as the Town of Vulcan, which supplies treated water to a 25-user co-op east of the Town in County No.2).

The data suggest that actual consumptive use by the municipalities in the study area increased substantially; it was estimated to be up 39% between 1984-87 and 1990-93, and 33% between 1990-93 and 1994-98. Withdrawals and consumptive use were largest and grew most noticeably at the Town of High River which supplies itself and a broad range of users in neighbouring parts of M.D. No. 31, including the study area's largest industrial facility – the Cargill cattle processing plant. In fact, the Town of High River and its related users receive 56% of the study area's withdrawals for the production of treated water. This is apparent by comparing the current withdrawals and consumptive use summary presented in Figure 2.

3.2 Non-Municipal Withdrawals and Consumptive Use

Forms, referred to as "water use returns" submitted annually to AENV by holders of water licences (with the larger licence holders generally providing better information), provided a second source of information on actual water consumption. Unfortunately, this source was not as available as expected. In the mid-1990s, AENV policy changed concerning enforcement of the reporting provision contained in the licences. The provision rapidly fell into disuse and in newly issued licences the wording has changed from submitting annual reports to requiring the licencee to collect the necessary data in case it is requested for examination by AENV. Based on review of several files – approximately a dozen of which contained water use returns, it became clear that:

- licenced withdrawals often exceed actual withdrawals; and

- the under-utilization of licenced withdrawals varies greatly between user categories – the largest discrepancies occur in non-irrigation and non-stockwatering agricultural licences where allocated amounts might be required during months of inadequate precipitation.

Inspection of the files containing several years of water use returns was valuable for making assumptions about the relationship between licenced withdrawals and actual consumption (see Section 5).

It should be noted that the water use return forms are not expected to be entirely reliable because of: the lack of accurate measurement or inconsistent measuring procedures, and the possible over-reporting of water use to avoid a possible reduction or reassignment of water volumes.

Master lists of non-irrigation licence files, prepared by AENV, indicate that there are currently 667 water licences or interim licences for withdrawals in the study area (Table 5). Most of these (88%) are in the agricultural sector, primarily for stockwatering. These licences are usually for small reservoirs located on minor tributaries, and typically require 1 to 5 acre-feet (1.2 to 6.2 dam^3) annually for stock but have considerably larger withdrawals to offset losses due to evaporation and seepage. According to AENV, several older licences for domestic users (who are not required to obtain licences but have their own reasons for doing so) are included in the stockwatering classification.

Only 8% of the 667 licence holders are of a municipal nature (this includes water co-ops and Hutterite colonies), and only 4% are industrial users.

Table 6 provides a summary of the key data provided in the licence documents, i.e. licenced withdrawal, estimated consumption, estimated loss and estimated return flow. The summary describes the volumes allocated for major uses in each river basin.

For clarity, non-irrigation agriculture was divided into stock watering and other (such as fish farms, market gardens, tree farms, waterfowl propagation, golf courses and parks). Municipal signifies licences held by towns and villages and specific municipal-related uses such as schools, recreation centres, fire protection systems, subdivisions, water co-operatives and Hutterite colonies. Industrial licence holders are companies involved in injection and other oil and gas uses, food processing, aggregate washing and other activities.

The major wetland licence related to Frank Lake stabilization is shown separately in Table 6. It is computed in Table 6 as: the High River average return flow (1235 dam^3) plus Cargill (1057 dam^3) plus the 1990-1998 average of 286 dam^3 from the Ducks Unlimited diversion intake, as previously discussed.

Table 7 summarizes expected consumptive uses based on current licences. The leading uses are stockwatering followed by industrial.

3.3 Relationship between Allocated Water Use and Actual Water Use

Table 8 presents, by river basin and major use, the compiled data on licenced withdrawals and expected consumption (as shown in licence documents) for the current year. Additional columns, labeled "Est. CONS", show best estimates of what actual consumption would have been in the current year assuming:

- 100% of expected consumption in stock watering due to evaporation and other losses from small reservoirs regardless of the amount of usage by the livestock;
- 50% of expected consumption in other non-irrigation agricultural uses, related to the likelihood that licences would be designed principally for dry summer months;
- recorded data from Table 4 for municipal use; and
- 70% of expected industrial consumption representing an average from a review of several water use return files.

No assumption was made about instances where some uncertainty occurs between consumption and return flows in rural areas. Hauling rural wastewater or sludge, from locations such as from R.V sites, to municipal treatment facilities is practiced in the study area. However, the practice is not believed to be widespread.

Table 8 includes estimates for a use not reflected in earlier tables. Rural households have a statutory right to withdraw up to 1 acre-foot (1.233 dam^3) annually for domestic purposes without a licence. Based on AENV Water Sciences Branch water well records, it is estimated that there are approximately 8,000 unlicenced domestic wells within the study area. To include these potential uses, it is assumed that the average consumption per unlicenced well would be at least one-tenth of an acre-foot per year or a total consumption of 1,000 dam^3 annually for the study area. This use is allocated according to the proportion of the rural population residing in each river basin.

Total current withdrawals and estimated consumptive use by sub-basin and type of use are graphically illustrated in Figure 2.

Although, the variability of water consumption over the year was not investigated in detail during this study, it would appear that peak demands for most use categories occur in months when river flows are typically low. This clearly has a strong bearing on water supply and delivery system considerations. The variations in demands and uses over the year are addressed elsewhere in modeling by AENV.

3.4 Summary of Estimated Actual Water Consumption

Licenced withdrawals and estimated actual consumption are the two water-related variables upon which projections in Section 5 of this report are based. Estimated total water withdrawals in the current year amount to 18,507 dam^3 and estimated actual consumption is 10,780 dam^3 for the study area plus the effluent return water to Frank Lake (2292 dam^3).

The breakdown of estimated actual consumption by river basin and by categories of use is given in Table 9. Approximately forty-eight percent (47.6%) of the total consumption is accounted for in the Highwood River sub-basin (excluding 2292 dam^3 of effluent return flow from High River and Cargill). Adding all of Frank Lake as a consumptive use in Table 9 would increase total consumptive use to 13,074 dam^3 with Frank Lake accounting for nearly 20% of the total (this assumes Frank Lake does not spill and lake evaporation is a consumptive use in this case). Among major use categories, stockwatering is the highest at 39.1% of the total (excluding the effluent return flow to Frank Lake).

3.5 Current Effluent Water Quality Considerations

Table 10 summarizes the quality of effluent from return flows within the study area. The data are based on one sample year and represent the most recent water quality measurements submitted to AENV by the municipalities and Cargill. These are either in the form of annual wastewater treatment plant reports or third-party water quality analyses. The data present a simplified summary of monthly averages, maximums and minimums although daily data are available. Water quality parameters other than those indicated are also sampled on a less intensive basis. These include: phosphorus or phosphate, Chemical Oxygen Demand (COD), Ammonia-N, Total Kjeldahl Nitrogen, Total Chlorine Residual, and Fecal Coliform counts.

The municipalities are currently operating within provincial limits in terms of water quality. Cargill experienced some recent problems with expanded operations, however, these have been rectified, and further wastewater treatment upgrades are expected to be commissioned in June 1999.

Total annual loadings of Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) are summarized in Table 10 based on the sample year of data. These loadings are expected to decrease in the near-term with recent upgrades at the Okotoks plant (December 1998) and planned upgrades at Cargill. It should be noted that effluent discharges are not directly to surface watercourses in several instances:

- Cargill discharges to Frank Lake and/or for alfalfa/hay irrigation.
- The Town of High River effluent is discharged to Frank Lake with some used for tree farm irrigation. Ducks Unlimited prefers the town's wastewater to assist in diluting Cargill's effluent.
- A portion of the rural population of M.D. 31 also discharges to Frank Lake (3 dam^3); and
- 6.7% of Okotoks effluent was used for irrigation in 1998.

Based on the above considerations and the values in Table 10, current measurable BOD and TSS loadings from return flows to the various rivers are estimated as follows:

Basin	Flow (dam^3)	BOD (kg/yr)	TSS (kg/yr)
Sheep	2,182	23,040	22,140
Highwood	79.6	334	661
Mosquito	251	1,505	2,107
Little Bow (Frank Lake)	2,655	21,000*	57,500*

*Maximums if all effluent in 1997 was directed to Frank Lake

Other data from municipalities on the quality of stormwater discharged into surface streams or rivers are limited and are not considered in the current work scope. Although mentions were made during interviews of waste hauling for spraying on farmland, no data were encountered on the environmental effects of such practices. Another increasing water quality concern is effluent from intensive livestock/feedlot operations in the form of groundwater infiltration. Data were not encountered on this nor was this a focus of the current study. Effluent from intensive livestock operations has typically been addressed through soil amelioration plans. More extensive detailed investigations are required to project potential long-term loadings from these indirect sources.

4.0 PROJECTED POPULATION AND ECONOMIC ACTIVITY

4.1 Factors Affecting Population Growth

Table 11 sets out 20 factors considered when examining trends affecting the study area's population. The factors vary from the tangible and well-understood highway expansion program to the nebulous effects of a possible change in Canada's political boundaries.

4.2 Characterization of Projected Economic Activity

The single most significant among all of the factors listed in Table 11 is the growth of Calgary as a metropolitan city and as the centre of an increasingly prosperous and diversified regional economy.

In recent years, the economy of Alberta has grown and become increasingly diversified. Data provided by Alberta Economic Development for the composition of GDP in 1985 and 1996 show:

- the portion of GDP contributed by the energy sector declined from 35.9% to 19.8%;
- substantial increases were registered in business and communication services (from 15.3% to 21.1%), manufacturing (6.7% to 10.6%) and finance (10.1% to 13.2%); there were smaller increases in transportation and utilities (from 9.6% to 11.8%) and retail and wholesale trade (from 8.0% to 9.9%).

The economy of the study area is not expected to be an exception to this general pattern.

Since the 1940s, Calgary's economy has been known for its "boom" and "bust" cycles attendant more often than not on the price of oil and government regulation of the Canadian oil industry. More recently, natural gas prices have taken on added significance. Price fluctuations in these commodities will likely continue. However, diversification of the provincial and Calgary economies means that the economic fallout from price drops is much less than before. In the past year, the fact that Calgary continues to grow while oil prices languish at the US$12-13/barrel level is witness to a new robustness in the local economy.

The agriculture and oil and gas sectors, the traditional mainstays, are still solid contributors. However, there are several others, which play a substantial role – light industry including food processing, retail and service businesses, recreation and tourism, and public administration.

The largest single employer in the study area is the Cargill meat packing plant in M.D. No. 31 between the hamlet of Aldersyde and the Town of High River. This plant's location -- in a corridor sandwiched between the key Highways 2 and 2A and the railway, and well served with natural gas and electric power -- appears to be of strategic significance to the region. With the cooperation of the Town of Okotoks, the Town of High River and M.D. No. 31, other businesses are establishing there and expectations are building that it will eventually serve the study area as an industrial hub. (Treated water for Cargill and the surrounding area is piped from the Town of High River under an agreement between the Town and M.D. No. 31.) Suggestions of future businesses, which might establish there, include added capacity at Cargill, a pork processing facility and even an electricity generating plant.

Other nodes or hubs of future economic activity are hard to discern at this time. There appears to be more potential for further intensive livestock development in M.D. No. 26 than in M.D. No. 31 or County No. 2. However, there was not a clear consensus among informants that this activity would challenge the predominance of cow-calf operations in the northern stretches of M.D. No. 26, which makes up the southern portion of the study area. A more likely area for intensive livestock expansion is further south of the study area, between Stavely and Granum.

Suggestions that recreation/tourism may become important in the south-west of the study area appear to stem from the promotional activities of Vulcan County No. 2 rather than concrete developments. However, this may well change once construction begins on the Little Bow River Reservoir and a workable inter-municipal development plan is drawn up between County No. 2 and M.D. No. 26. Certainly, County No. 2 appears to have had success in establishing recreational developments along McGregor Lake to the east and south-east of Vulcan.

4.3 Alternative Population Projections Relevant to the Study Area

The percentage increase in population from year to year or over a 5-year census period is a critical factor in making population projections. Five existing sets of population projections were encountered for the study area:

- Statistics Canada – a custom order of projections for Census Sub Divisions in the Bow River Basin carried out for the February 1998 updating of the document "Population and Economic Outlook for the Bow River Basin – Bow Basin Plan" (authored by Multiplan Solutions for AENV Environmental Service – Prairie Region). These projections, which benefit from 1996 federal census data, cover ten of the 11 municipal jurisdictions in the study area and extend to the year 2016. They form the most rigorously produced set of population projections that correspond to the study area. It is noteworthy that Statistics Canada is not comfortable issuing population projections beyond 2016 at this time.

- Calgary Regional Planning Commission – one of its last publications called "Prospect: Population Projections for the Calgary Region." Projections to the year 2011 are provided for Calgary and each of the municipalities surrounding it, including Okotoks, High River and M.D. No. 31. The projections, which incorporate low, medium and high migration assumptions, utilize 1991 federal census data.

- Alberta Treasury, Statistics Branch – a publication called "Alberta Population Projections Census Divisions 1995-2011." This source, which is based on 1991 federal census data, provides projections to the year 2011 for Census Division 6, which includes Calgary and its surrounding area. Alberta Treasury is currently preparing a new set of Census Division projections to 2016 based on 1996 federal census data. It should be noted that Alberta Treasury, upon which most provincial departments rely for long-term population forecasts, is not willing to consider a forecasting period beyond 2016 at this time.

- Alberta Health, Health Surveillance Branch – a publication called "Population Projections for Alberta and its Health Regions: 1996-2016." These projections are for health authorities, including the Headwaters Health Authority, which incorporates all of the study area plus additional communities such as Canmore, Claresholm and Vulcan. The projections are based on 1996 federal census data and extend to the year 2016.

- City of Calgary Finance Dept. – a publication entitled "The Calgary Economic Outlook 1998 through 2003." This source presents a population and employment table for 1995-2026, based on the City's DYNACAL computer model. The table clearly supports the view that the growth rates being experienced/expected in the 1996-2001 period are not sustainable.

The municipalities in the study area were also asked for information on any population forecasts they had prepared for themselves. Only the Town of High River has conducted a formal forecasting exercise. Several municipalities prefer to focus resources on preparing their next municipal census (to better understand the present situation) and to watch trends in Calgary and neighbouring municipalities.

One municipality in the study area indicated that it relies on estimates of residential building permits in the City of Calgary as a guide for its own future growth. An attempt by the author to locate long-term forecasts for housing permits in the City of Calgary was not successful. The City does not currently issue forecasts for this indicator beyond the year 2003. The reason for this stems from the uncertainty over where baby-boomers will choose to live once they begin to enter retirement.

Table 12 and a portion of Table 13 (namely the 2001 through 2016 columns) set out the pertinent population totals and five-year growth rates from each of these forecasting exercises. It should be stated that each of these exercises utilized a projection model, often calculating birth, death and migration components separately for different age-sex cohorts, or (as with the City of Calgary) incorporating a detailed series of employment-generation assumptions. Four of the five agencies did not forecast beyond 2011 or 2016. The City of Calgary's forecast goes to 2026.

Even though the geographic coverage of these forecasts differs, it is still possible to compare the five-year growth rates. The forecasts, in order from high to low percentage increases, are as follows:

- Calgary Regional Planning Commission - average 11.2 – 14.4%;
- The City of Calgary (with no rural area) - 16.5% in the first 5 years then 9.8 – 10.9% thereafter;
- Alberta Health - 11.2% and declining gently to 9.1%;
- Statistics Canada - 14.2% and declining from 10.2% to 7.3%; and
- Alberta Treasury – average 5.8 – 7.5%;

Based on this comparison, the Statistics Canada projections are assumed to provide a reasonable low growth projection scenario for the study area. Boosting the Statistics Canada figures by 10% provides a medium growth scenario resembling the Alberta Health projections and boosting the Statistics Canada projections by 20% provides a high growth scenario similar to the City of Calgary and Calgary Regional Planning Commission projections.

4.4 Projected Population by River Basin and Municipality – Low, Medium and High Growth Cases

Based on the above considerations, the Statistics Canada projections, specifically produced for the region for 2001, 2006, 2011 and 2016, were taken as the "low case" growth projections for the current study (see Table 13). Populations for the years beyond 2016 were calculated according to the average of the three five-year growth rates covering the 2001-2016 period. The growth rate for the five-year period 1996-2001 over which there was substantial disagreement in the various forecasts was not utilized in this straight-lining process. Under the "low case" projection, the study area is projected to have a 2021 total population of 56,396 and a 2046 total population of 85,306.

The "middle case" projections (shown in Table 14) were derived by boosting the Statistics Canada five-year growth rates for the years 1996-2016 (as shown in Table 13) by 10%. As before, populations for the years beyond 2016 were calculated according to the average of the three five-year growth rates covering the 2001-2016 period. Under this "medium case" projection, the study area is projected to have a 2021 total population of 58,931 and a 2046 total population of 92,844.

For the "high case" projections (shown in Table 15), the five-year growth rates for the years 1996-2016 shown in Table 13 were boosted by 20%. As before, populations for the years beyond 2016 were calculated according to the average of the three five-year growth rates covering the 2001-2016 period. The high-case five-year growth rates rank very close to those in the Alberta Health projections (which in the consultants' view are too positive for the study area, largely on account of the inclusion in the Headwaters Health Authority of the Town of Canmore). Under the "high case" projection, the study area is projected to have a 2021 total population of 61,559 and a 2046 total population of 100,998.

Figure 3 illustrates the low, medium and high growth population projections for the four basins and the total study area.

4.5 Anticipated Trend in Livestock Inventories

Livestock specialists are generally unwilling to forecast livestock numbers even for the near term and there appear to be no livestock forecasts published on a regional basis.

Future trends have been analyzed in an April 1998 study conducted by Alberta Agriculture, Food and Rural Development called "The Changing Structure of Farm Businesses as the Industry Expands to the Year 2005." In addition to further expansion in average farm size, there is an expectation that livestock populations will grow province-wide, mainly through the addition of more intensive livestock operations and feedlots.

In the northern portions of the study area, however, there may be few opportunities for such expansion. With a substantial and growing number of acreages and other country residential developments in M.D. No. 31, there is a high probability of conflicts arising between intensive livestock operators and non-farm rural residents over issues such as odor, dust and water quality. Conflicts of this nature have been commonplace in recent years in the County of Lethbridge and its neighbouring municipalities in what has been dubbed "feedlot alley."

There is currently uncertainty over changes in provincial regulations that would govern the granting of licences to owners of intensive livestock operations and feedlots. Up to now, these matters have largely come under the jurisdiction of municipal governments – and the positions taken by different municipal governments have varied all the way from opposition to support. Two regulations of critical importance are the setting of minimum separation distances between intensive livestock operations and existing residences, and the acreage, technique and timing requirements for spreading or incorporating manure into the soil.

Alberta Agriculture, Food and Rural Development officials agree that forecasting livestock populations is a tricky endeavour. However, they believe the long-term prospects for additional export trade are strong, both to the U.S. and to Asia. With its strongly pro- agricultural municipal government, M.D. No. 26 seems more likely as a host for future additional intensive livestock operations than M.D. No. 31 or County No. 2. In any event, the evolving regulatory framework (changes are under active discussion) will likely permit near-term intensification in all three jurisdictions unless environmental concerns create obstacles. Research on the capacity of different areas to host intensive livestock farming is currently underway through AAFRD's Livestock Expansion and Development (LEAD) Team.

5.0 PROJECTED WATER USE

5.1 The Relationship between Population, Economic Activity and Water Use

Section 3 concluded with a picture of licenced water withdrawals and estimated actual consumption of water in the study area for the current year.

The next step in the analysis involved calculation of per capita licenced withdrawals and per capita estimated actual consumption for the current year. These numbers are used for forecasting those components of overall demand which are directly related to population growth. Relevant information from Section 4 was used in making assumptions about growth patterns affecting other components of water demand.

5.2 Projected Water Withdrawals and Consumptive Use – 2021

The assumptions made about the growth in licenced water withdrawals and actual consumption of water between the current year and 2021 (with significant low and high assumptions for sensitivity analysis in brackets) were as follows:

- stockwatering – plus 20% over current (low and high increases of 10% and 30% over current were applied, respectively);
- other non-irrigated agriculture – plus 50% over current (low and high increases of 25% and 75% over current were applied, respectively);
- municipal – 2021 population times current per capita withdrawal/consumption reduced by 5% to reflect conservation measures (a 10% reduction was applied for the low case and no reduction was applied for the high case sensitivities);
- industrial – 2021 population times the current per capita industrial withdrawal/consumption rate plus the addition of one industrial user with 1,000 dam^3/year of withdrawal and 400 dam^3/year of consumptive use – roughly the equivalent of the present two-shift Cargill meat packing plant; the additional industrial user is assumed to be located in the Highwood River Basin (low and high cases assumed one-half and two times the above added plant rates, respectively, plus the per capita demands);
- rural domestic – 2021 population times current per capita consumption (low and high cases were the same, times the low and high population estimates) ; and

- Frank Lake stabilization – not projected

Another trend not factored into the above assumptions relates to use by rural residents of treated water hauled from municipal loading stations. There are currently stations of this kind operating in Aldersyde and Blackie (in M.D. No.31), Longview, Turner Valley, High River, Nanton and Vulcan. The implementation of the Water Act on January 1, 1999, combined with licence holders' concerns over the quality of groundwater in some parts of the study area will tend to reduce some sourcing by rural residents of water from wells. There may be a corresponding increase in hauling of treated water from municipally run pay-as-you-go hauling stations.

By the year 2021, the projected Town of High River and industrial return flows will be double current conditions. This will have significant implications on flows directed to Frank Lake and related water quality issues. Increased effluent irrigation is another future possibility.

Table 16 presents the resulting projections of licenced water withdrawals for 2021. The medium case is approximately 52% higher than the current level (28,087 dam^3 versus 18,507 dam^3 including the 286 dam^3 to Frank Lake in the current year). However, the differences between the cases are minor (approximately ±10%), given what are considered to be relatively significant low and high case demand assumptions. This is due to the fact that the major increases are due to general per capita increases over time.

Utilizing the same growth assumptions, the resulting projections of actual water consumption for 2021 are 14,131 dam^3 for the low case, 15,446 dam^3 for the medium case and 16,988 dam^3 for the high case (Table 17). Again, the difference between the three cases is minor at about ±10% from the medium case.

5.3 Projected Water Withdrawals and Consumptive Use – 2046

To move from 2021 to 2046, the following growth assumptions (and low, high sensitivities) were applied:

- stockwatering – plus 10% over 2021. Growth is reduced from the previous period due to fewer opportunities to expand operations while satisfying environmental requirements. Low and high increases were 5% and 15% over 2021, respectively;

- other non-irrigated agriculture – plus 30% over 2021. Growth is reduced from the previous period due to saturation of certain uses such as golf courses and equestrian facilities and increased trends towards conservation. Low and high increases were 20% and 40% over 2021, respectively;

- municipal – 2046 population times current per capita withdrawal/consumption reduced by 7.375% (i.e. a 2.5% decline on top of the 5.0% decline registered between 2021 and the current year). The assumption of a slower decline is because the easiest/cheapest consumption savings have already been achieved. Low and high cases applied 12% and 0% per capita reductions over current rates, respectively;

- industrial – 2046 population times the current per capita industrial withdrawal/consumption rate plus the addition, in the Highwood River Basin, of two industrial users with 1,000 dam^3/year of withdrawal and 400 dam^3/year of consumptive use – roughly the equivalent of two present-day Cargill meat packing plants. Low and high cases applied are minus one-half and plus two times the above added plant demands plus the per capita industrial demands; and

- rural domestic – 2046 population times current per capita consumption. Low and high cases were the same times the low and high population estimates.

- Frank Lake stabilization – not projected

Table 18 presents the projections of licenced water withdrawals for 2046 ranging from 35,428 dam^3 in the low case, to 40,811 dam^3 in the medium case and 48,146 dam^3 in the high case. The differences in the forecasts vary by ±15 to 18% from the medium case.

Table 19 shows projected actual consumption for the study area for 2046. The amounts are 18,819 dam^3 for the low case, 21,497 dam^3 for the medium case and 24,929 dam^3 for the high case. Again, the difference between the three cases is minor.

As with the previous three tables, the river basin making the largest contribution to the study area totals is the Highwood. The projected demands and proportional split over the study area are illustrated in Figures 4, 5 and 6. Figures 4 and 5 break down withdrawals and consumptive use by use category, respectively, for the medium case. Figure 6 illustrates the sensitivities of total withdrawals and consumptive use by sub-basin.

5.4 Summary of Projected Water Withdrawals, Consumption and Return Flow

A summary of the various findings for licenced water withdrawals and actual consumption is presented in Table 20 along with high/low sensitivities. Return flow, which is taken to be withdrawals less consumption, is also shown. Withdrawals and consumption are expected to increase by 52% and 43%, respectively, between the current year and 2021. Over the following 25 years, withdrawals are expected to rise another 45% and consumptive use another 39%.

Projected withdrawal and consumptive use differences from the medium to low and high growth cases are approximately ±10% in year 2021 and from -14.2% to +18.0% by year 2046. These differences do not consider diversions to Frank Lake. The percentage differences in the return flow projections are higher – ranging from –16.3% to +20.2%. The return flow values include any effluent that is directed to Frank Lake.

Readers may wish to compute additional sensitivities from the data provided in this report. The situation with an electricity generating plant (if it were to materialize) would be more complex as there exists the possibility of supplying the large volumes of required water from municipal wastewater plant effluent streams.

Other sensitivities could also be run based on alternative assumptions concerning Frank Lake stabilization. One pertinent question is to what extent to consider Frank Lake as a sink (and therefore flows into it as "consumption" or "loss") when the water body has overflowed into the upper Little Bow Basin twice since 1995.

5.5 Per Capita Consumption Rates

As indicated above, it is expected that municipal consumption per capita may decrease moderately in the medium term with a further slight decline in the long-term.

The rationale for expecting such changes is the increasing awareness among municipal governments of policy tools that are available for promoting water conservation. Interviews with municipal administrators in the study area showed a knowledge of, and in some instances, extensive experience with policy levers such as:

- increased water (and sewer) charges, increases in water charges at certain times of the year (such as at times of greatest demand), and levying of charges on non-traditional users (such as construction companies which use water for dust control, settling dirt and curing concrete);
- restrictions on specified water uses at times of greatest demand (such as bans on watering of residential lawns or restricted covenants on lawn watering in acreages);
- appeals and educational campaigns in favour of low water-use devices in new construction (such as low water-use toilets and shower-heads in new residential construction);
- use in municipally-owned landscaping of drought-resistant plant species (xeriscaping);
- targeted educational campaigns in schools and other segments of the community that are linked to broad issues of environmental protection and sustainable development;

- metering (and checking/upgrading of meters) to gauge accurately actual water used and invoice users for that amount; and

- leak detection awareness programs to assist water users to control costs and to minimize losses in the distribution system.

The most extensive use of such policy levers in the study area is at the Town of Okotoks. The municipality is even preparing a water module for its GIS system to pinpoint high-consumption areas. In connection with its sustainable development policy, the Town of Okotoks has set itself a target of reducing residential per capita water consumption by 25% over the next 15 years. Okotoks current gross withdrawal rate is approximately 500 liters/person/day (l/p/d).

Current municipal gross water withdrawals, as indicated in Table 6, vary from under 400 l/p/d at Nanton to 620 l/p/d at Vulcan. The withdrawal rate per capita at High River is complicated by significant other rural users. Excluding High River, the average withdrawal rate from the other towns is approximately 550 l/p/d (120 gal/person/day) or 470 l/p/d as an average of total withdrawal to total population. Withdrawals include domestic, public, commercial and small industrial uses within the towns.

As a comparison, water demands for acreages and country residential rural areas in southern Alberta are typically based on a rate of 450 l/p/d (100 gal/person/day) where there are restrictions on lawn watering. A review of rural acreages and country residential areas around Calgary indicate consumption may be slightly above 2 m^3/day where there are no restrictions on lawn watering. Assuming an average of 3.5 persons/household, this rate is about 25% higher at 570 l/p/d (125 gal/person/day).

The above discussion suggests that the projected average reductions in withdrawals and consumptive use of 5% in the first 25 years and a further 2.5% in the second 25 years are quite achievable. The low case demand assumption of a total 12% reduction over the 50 year projection period may, in fact, be quite realistic. By reducing per capita withdrawals by 25%, for example, total municipal withdrawals would reduce by another 2,100 dam^3 from the low demand case at year 2046.

Because of increases in water conservation, average per capita consumptive use in the study area (excluding Frank Lake) is projected to decrease for the medium case by over 1 m^3/person/year from 303 m^3/person/year in the current year to 262 m^3/person/year in 2021 and to 232 m^3/person/year by year 2046.

Consumption rates for different livestock species were also obtained but they are of little help in checking the projections. This is because of the very large losses incurred through evaporation and seepage from the many small reservoirs and dugouts that have been constructed specifically for stockwatering.

5.6 Future Water Quality Considerations

Applying the above water demand projections directly to the current status of the wastewater treatment plants would result in upper limit projections on effluent loadings. These projections would correspond to increased municipal plant loadings in the order of 80% from 1998 to 2021 and a further increase of about 60% from 2021 to 2046.

Increases of this magnitude, of course, will not likely occur because of plant upgrades – both enforced and voluntary due to improving technologies. For example, the 60% reductions expected in BOD and TSS at the recently upgraded Okotoks plant (which appear realistic based on initial numbers in December, 1998), will alone account for a reduction of about 35% of the total study area loadings projected in 2021.

Recent trends have seen an increase in effluent irrigation practices resulting in reduced return flows to the river systems. This trend is expected to continue in the near term, although a saturation level of locally viable areas to irrigate may be expected in the future due to both economics and the South Saskatchewan Basin Water Allocation Regulation. In addition, there may be increased pressure to protect instream flows.

An increasing concern with the expanding towns will be the need to reduce nutrients in the future. Okotoks may be the first to require upgraded nutrient removal based on its size. AENV usually requires upgraded nutrient removal for plants servicing in excess of 25,000 population.

Nutrient loadings on Frank Lake may also become an increasing concern in the future. Planned upgrading of the Cargill plant to reduce phosphorus levels from current levels of approximately 28 mg/l to between 5 and 10 mg/l will help alleviate these concerns. Future plants can be expected to have similar or improved effluent quality from that expected at Cargill in the near future.

BOD and TSS loadings that might be anticipated, based on the medium case demand projections and our current understanding of expected plant upgrades, are presented in Table 21. This illustrates the significant variability that can occur depending upon the assumptions, specifically, when or if system upgrades are implemented. Although the projections in Table 21 are highly speculative, they do indicate that significant increased loadings can be expected to develop in the study area unless adequate removal guidelines are established and adhered to in the future.

Table 1 - HISTORICAL POPULATION DATA BY MUNICIPALITY AND RIVER BASIN

Census Sub Divisions	1981 Census	1986 Census	1991 Census	1996 Census
SHEEP RIVER BASIN				
Okotoks	3,847	5,214	6,723	8,510
Black Diamond	1,444	1,486	1,623	1,811
Turner Valley	1,311	1,271	1,352	1,527
Rural (59% of MD 31)	5,674	5,513	6,399	8,045
Sub-total	**12,276**	**13,484**	**16,097**	**19,893**
% increase over 5 years		9.8%	19.4%	23.6%
HIGHWOOD RIVER BASIN				
High River	4,845	5,096	6,269	7,359
Longview	301	276	271	303
Eden Valley Reserve	353	432	370	432
Rural (25% of MD 31)	2,432	2,363	2,743	3,448
Sub-total	**7,931**	**8,167**	**9,653**	**11,542**
% increase over 5 years		3.0%	18.2%	19.6%
MOSQUITO CREEK BASIN				
Nanton	1,641	1,562	1,589	1,665
Rural (15.5% of MD 26)	702	734	738	793
Sub-total	**2,343**	**2,296**	**2,327**	**2,458**
% increase over 5 years		-2.0%	1.4%	5.6%
UPPER LITTLE BOW BASIN				
Vulcan	1,495	1,420	1,466	1,537
Rural (5% of County 2)	185	183	182	191
Sub-total	**1,680**	**1,603**	**1,648**	**1,728**
% increase over 5 years		-4.6%	2.8%	4.9%
Total	**24,229**	**25,550**	**29,725**	**35,620**
% increase over 5 years		5.4%	16.3%	19.8%

Source: Statistics Canada, except for rural portions of M.D. No. 31, M.D. No. 26 and County No. 2 which have been estimated by the author based on percentage of CSD covered by the study area.

Table 2 - LISTING OF APPROVED CONSTRUCTION PROJECTS

Sector/Company Name	*Project Description*	*Project Location*	*Cost ($ millions)*	*Construction Schedule*	*Remarks*
MAJOR PROJECTS (VALUED AT OVER $2 MILLION)					
AgPro Grain	Full Service Facility	Vulcan	15.0	1998-1999	Under construction
Canada Safeway	New Store	Okotoks	4.0	1998-1999	
Westfair Foods	Gocery Store	Okotoks	2.8	1998	
Alberta Public Works, Supply and Services	Reservoir Development, Dams and Diversion Canals	L. Bow River, Clear L., Highwod River	53.3	1999-2001	Approved
Alberta Transportation and Utilities	Hwy. 22 Widen and Reconstruct	Longview to Black Diamond	5.6	1998-1999	
Alberta Transportation and Utilities	Hwy. 2A Upgrade	Okotoks	2.0	1998-1999	
Alberta Education	New School and Portables	High River	5.7	1998-1999	
Alberta Education	Modernization	Okotoks	5.5	1998-2000	
Alberta Education	New School	Okotoks	3.8	1998-2000	
Best Western	Hotel	High River	4.0	1998-1999	
Valiant Country Place	Western Entertainment and Destination Facility	Okotoks	141.0	1997-1999	Under construction in phases
OTHER PROJECTS (VALUED AT UNDER $2 MILLION)					
Cosmos Collision	Auto Shop Renovation	Okotoks	0.12	1998	Completed
Calstar Construction	Warehouse	Okotoks	0.14	1998	Completed
Steelbrace Construction	Warehouse	Okotoks	0.23	1998	Completed
Muller-Warden Inc	Super Drug Mart Store	Okotoks	0.47	1998	Completed
Southridge Chrysler	Car Dealership	Okotoks	0.70	1998	Planned
Town of Turner Valley	Water Treatment Plant	Turner Valley	1.85	1999	Announced
Town of High River	Police Admin Building	High River	1.80	1998-1999	Under construction
Christ the Redeemer School Division	School Portables	Okotoks	0.28	1998	Completed
W. Parker Architects	Church	Okotoks	0.90	1998-1999	Under construction
A&J Homes	Multi-unit Condos	Okotoks	0.67	1998	Completed
Sherly Laulnger	Big Rock Country Lodge	Okotoks	1.40	1998-1999	Under construction

Sources: Alberta Economic Development, Strategic Resources Division, "Inventory of Major Alberta Projects - December 1998" and "Inventory of Alberta Regional Projects - January 1999"

Table 3 - HISTORICAL LIVESTOCK POPULATION INVENTORIES

	Year	Cattle & Calves	Pigs	Sheep & Lambs	Hens & Chicks
M.D. of Foothills No.31	1981	117,258	11,642	8,940	598,412
	1986	90,228	12,408	8,407	x
	1991	107,490	15,899	14,351	612,230
	1996	170,629	9,482	9,209	455,612
M.D. of Willow Creek No.26	1981	128,099	27,191	4,561	142,316
	1986	110,345	32,234	6,690	91,284
	1991	132,558	32,247	17,884	167,886
	1996	186,160	35,793	11,539	200,295
County of Vulcan No.2	1981	47,780	16,649	653	69,115
	1986	36,491	17,578	2,129	56,617
	1991	46,301	33,873	7,733	48,275
	1996	78,131	30,948	4,091	69,703

Source: Statistics Canada Census of Agriculture - 1981, 1986, 1991 & 1996

Note: Data have not been adjusted to accout for the portions of each municipality that lie within the study area.

Table 4 - SUMMARY OF ACTUAL MUNICIPAL WATER WITHDRAWALS AND CONSUMPTIVE USES

Municipality	Gross Diversion (DAM^3)			Return Flow (DAM^3)			Consumptive Use (DAM^3)		
	Average by Period			Average by Period			Average by Period		
	1984-87	1990-93	1994-98	1984-87	1990-93	1994-98	1984-87	1990-93	1994-98
SHEEP									
Town of Okotoks	1132	1264	1551	905	913	1137	227	351	414
Town of Black Diamond	459	401	396	n/a	n/a	618	75(est.)	80(est.)	90(est.)
Town of Turner Valley	n/a	n/a	293	n/a	n/a	249	70(est.)	70(est.)	75(est.)
Sub-Total Sheep							**372(est.)**	**501(est.)**	**579(est.)**
HIGHWOOD									
Town of High River & Rural Users (note ii)	1700	2669	2371	n/a	1794	1235	560(est.)	875	1136
Cargill	0	770	1455	0	672	1057	0	98	398
Other M.D. of Foothills									
Blackie	n/a	n/a	47	0	0	0	37(est.)	42(est.)	47
Cayley	25	n/a	32	0	0	0	25	28(est.)	32
Village of Longview	55	n/a	76	38	n/a	75	17	17(est.)	17(est.)
Eden Valley Reserve	n/a	n/a	32	0	0	0	28(est.)	30(est.)	32
Sub-Total Highwood							**667(est.)**	**1090(est.)**	**1662(est.)**
MOSQUITO									
Town of Nanton	n/a	182	239	242	285	246	100(est.)	100(est.)	100(est.)
Sub-Total Mosquito							**100(est.)**	**100(est.)**	**100(est.)**
LITTLE BOW									
Town of Vulcan(note iii)	314	325	348	0	0	0	314	325	348
Sub-Total Mosquito							**314**	**325**	**348**
TOTAL							**1453(est.)**	**2016(est.)**	**2689(est.)**

SOURCE: author calculations from water and wastewater treatment plant records supplied by municipalities and AEP
NOTES: (i) n/a denotes data not available
(ii) rural users in M.D. No. 31 receiving piped water from the Town of High River, other than Cargill, include Aldersyde, Saddle Brook Industrial Park, Mapleleaf Water Co-op and Mazeppa Gas Plant.
(iii) some rural users in the County of Vulcan receive piped water from the Town of Vulcan.
(iv) entries accompanied by (est.) have been estimated by the author
(v) some averages may be calculated over less years than shown on column header

Table 5 - NUMBERS OF CURRENT WATER LICENCE HOLDERS IN THE STUDY AREA

River Basin	Stock Watering	Other Agricultural (non-Irrigation)	Municipal	Industrial	TOTAL
Sheep	163	23	21	12	219
Highwood	135	8	8	7	158
Mosquito	200	5	12	5	222
L. Bow	54	0	12	2	68
Total	552	36	53	26	667
Percent of Total	82.8%	5.4%	7.9%	3.9%	100.0%

Table 6 - SUMMARY OF CURRENT LICENCED WITHDRAWALS AND CONSUMPTIVE USE (DAM^3)

USE		SHEEP RIVER				HIGHWOOD RIVER				MOSQUITO CREEK				LITTLE BOW RIVER			
		MAD	CONS	LOSS	Return	MAD	CONS	LOSS	Return*	MAD	CONS	LOSS	Return	MAD	CONS	LOSS	Return
Agric./Stock	Stockwatering	912	308	604	0	1830	1254	576	0	1,049	691	358	0	429	306	123	0
Other Agric.	Fish	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gardens	136	136	0	0	33	33	0	0	0	0	0	0	0	0	0	0
	Wetlands	23	0	23	0	96	96	0	0	0	0	0	0	0	0	0	0
	Frank Lake Stabn.**	0	0	0	0	286	0	286	0	0	0	0	0	0	0	0	0
	Parks	192	189	4	0	321	321	0	0	0	0	0	0	0	0	0	0
	Other	132	127	5	0	4	4	0	0	150	148	2	0	0	0	0	0
	Sub-total	485	452	33	0	740	454	286	0	150	148	2	0	0	0	0	0
Municipal	Towns & Villages	3259	653	0	2605	2393	634	0	1759	887	306	21	560	296	296	0	0
	Other Municipal	0	0	0	0	0	0	0	0	0	0	0	0	160	125	36	0
	Schools	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Recreation	69	35	35	0	0	0	0	0	0	0	0	0	0	0	0	0
	Camps	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Subdivisions	12	12	0	0	51	51	0	0	0	0	0	0	0	0	0	0
	Co-Ops	2	2	0	0	2	2	0	0	0	0	0	0	0	0	0	0
	Sub-total	3350	710	35	2605	2446	687	0	1759	887	306	21	560	456	420	36	0
Industrial	Aggegate Washing	62	49	12	0	70	64	6	0	0	0	0	0	0	0	0	0
	Injection	1454	1454	0	0	1651	1651	0	0	0	0	0	0	0	0	0	0
	GasPlant/Petrochem	49	49	0	0	2	2	0	0	0	0	0	0	0	0	0	0
	Remediation	69	69	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ind'l Processing	0	0	0	0	1195	2	59	1133	0	0	0	0	0	0	0	0
	Other Industrial	0	0	0	0	0	0	0	0	184	28	0	155	37	37	0	0
	Sub-total	1634	1621	12	0	2919	1720	65	1133	184	28	0	155	37	37	0	0
TOTAL		6381	3092	684	2605	7934	4115	927	2892	2270	1173	382	715	922	763	159	0

TOTAL STUDY AREA	MAD	CONS	LOSS	Return
	17507	9143	2152	6213

Source: Author calculations from AEP files.

Notes:
(i) Numbers may not add exactly due to rounding.
(ii) MAD indicates Mean Annual Diversion (i.e. withdrawal).
(iii) CONS indicates expected consumptive use.
(iv) LOSS indicates expected losses due to evaporation, infiltration, etc.
(v) Return indicates expected return flow.
(vi) Return* values shown above for the Highwood River include Town of High River (1994-98 average return of 1235 dam^3) and Cargill Industrial Processing (1994-98 average return of 1057 dam^3) which are directed to Frank Lake in the Little Bow basin.
(vii) **Withdrawal licence from Highwood River for Frank Lake Stabilization in addition to (vi) above is up to 2466 dam^3 (2000 ac-ft) and is assumed as 286 dam^3 based on the 1990-1998 average observed plus the return flows indicated in Note (vi).

Table 7 - SUMMARY OF EXPECTED CONSUMPTIVE USE (FROM LICENCES) - DAM^3 - CURRENT YEAR

USE	SHEEP	HIGHWOOD*	MOSQUITO	LITTLE BOW	STUDY AREA
AGRI (non-irrig.) stockwatering	912	1,830	1,049	429	4,221
AGRI (non-irrig.) other	485	740	150	0	1,375
MUNICIPAL	745	687	327	456	2,214
INDUSTRIAL	1,634	1,785	28	37	3,484
TOTAL	**3,775**	**5,042**	**1,555**	**922**	**11,294**

Notes: (i) Consumptive uses shown here are the sum of all withdrawals (MAD) minus return flows indicated in Table 6.

(ii) Numbers may not add exactly due to rounding.

(iii) * Includes 286 dam^3 assumed diverted from Highwood to Frank Lake. The 2292 dam^3 return flows from the Town of High River and Cargill directed to Frank Lake in the Little Bow basin could also be added here to be a Consumptive Use on the Highwood River. This would bring the total Highwood River Consumptive Uses to 7334 dam^3.

Table 8 - SUMMARY OF CURRENT LICENCED WITHDRAWALS, EXPECTED CONSUMPTION (AS SHOWN IN LICENCES) AND ESTIMATED CONSUMPTION (DAM^3)

Basin	Stockwatering			Other Non-Irrigation Agricultural			Municipal			Industrial			Rural Domestic (Unlicenced)	Frank Lake Stabilization	Total		
	Licenced WD	Expd. CONS	Estd. CONS	Licenced WD	Expd. CONS	Estd. CONS	Licenced WD	Expd. CONS	Estd. CONS	Licenced WD	Expd. CONS	Estd. CONS	Estd. WD/CONS	Estd. WD/CONS	Licenced WD	Expd. CONS	Estd. CONS
SHEEP	912	912	912	485	485	243	3,350	745	579	1,634	1,634	1,144	645	0	7,026	4,421	3,522
HIGHWOOD	1,830	1,830	1,830	454	454	227	2,446	687	1,264	2,919	1,785	1,250	276	286	8,211	5,318	5,133
MOSQUITO	1,049	1,049	1,049	150	150	75	886	327	100	184	28	20	64	0	2,333	1,618	1,308
LITTLE BOW	429	429	429	0	0	0	456	456	348	37	37	26	15	0	937	937	818
TOTAL	4,220	4,220	4,220	1,089	1,089	545	7,138	2,215	2,291	4,774	3,484	2,439	1,000	286	18,507	12,294	10,780

Notes:

WD = withdrawal, CONS = Consumptive Use, Expt. = Expected as per AEP files, Estd. = Estimated

Numbers may not add exactly due to rounding

(I) Rural Domestic (unlicenced) and Frank Lank Stabilization have been added to each of the three columns in the total category.

(ii) estimated consumption assumed to be 100% of expected consumption in stockwatering and 50% in other non-irrigation agricultural uses

(iii) estimated consumption for municipal uses is based on recorded data

(iv) estimated consumption for industrial is assumed to be 70% of expected consumption based on report files.

Table 9 - SUMMARY OF ESTIMATED WATER CONSUMPTION BY RIVER BASIN AND MAJOR USE CATEGORIES (DAM^3) - CURRENT YEAR

USE CATEGORY	SHEEP	HIGHWOOD	MOSQUITO	LITTLE BOW	TOTAL	% OF TOTAL
Stockwatering	912	1,830	1,049	429	4,220	39.1%
Other Non-Irrig.Agric.	243	513	75	0	831	7.7%
Municipal	579	1,264	100	348	2,291	21.2%
Industrial	1,144	1,250	20	26	2,440	22.6%
Rural Domestic (Unlicenced)	645	276	64	15	1,000	9.3%
Total	**3,523**	**5,133**	**1,308**	**818**	**10,782**	100.0%
Percentage of Total	32.7%	47.6%	12.1%	7.6%	100.0%	

Notes: (I) Numbers may not add exactly due to rounding.

(ii) Other non-irrigation agriculture above includes 286 dam^3 for Frank Lake stabilization in the Highwood basin.
The other 2292 dam^3 return flows from High River and Cargill directed to Frank Lake are not included in the above.

Table 10 - SUMMARY OF MUNICIPAL & INDUSTRIAL TREATMENT PLANT EFFLUENT WATER QUALITY FOR SPECIFIED YEARS

		Water Quality Parameter					Total Volume for the Year[6]		
Municipal Plant (Year of Data)		BOD_5 (mg/l)	TSS (mg/l)	DO (mg/l)	pH	Temperature (Degrees C)	Flow (m^3)	BOD (kg)	TSS (kg)
Provincial Limit In Effect Guidelines for Protection of Aquatic Life[1]		<25	<25	5.5 - 9.5[2]	6.5 - 9.0	Note [3]			
Longview (1998)	Max.	8	15	4.5	7.84	15			
	Min.	1	5	0.4	7.21	9			
	Avg.	4.2	8.3	1.73	7.57	11.6	79,610	334	661
Black Diamond (1997) Westend Regional	Max.	11.4	9.6		8.8				
	Min.	0.97	1.09		7.6				
	Avg.	4.31	3.16		8.11		842,250	3,630	2,662
Okotoks[4] (1998)	Max.	28.9	20.2	4.1	7.19	17.7			
	Min.	8.1	7.92	1.7	6.22	12.9			
	Avg.	15	14.8	2.6	6.82	15.4	1,436,260	20,806	20,874
High River (1997)	Max.	14.3	14.2	12.1	7.9	19.1			
	Min.	2.2	3.5	3	7.3	0.6			
	Avg.	6.1	8.5	6.6	7.6	8.3	1,237,220	7,547	10,516
Nanton (1998)	Max.	7.2	15.1	6.2	7.5	21.1			
	Min.	3.9	3.9	3.7	7.2	8.7			
	Avg.	6	8.4	4.8	7.3	13.6	250,880	1,505	2,107
Industrial Plant (Year of Data)		BOD_5 (mg/l)	TSS (mg/l)	Fec. Col. (mpn/100ml)	pH	Ammonia-N (mg/l)	Total Volume for the Year Flow (m^3)	BOD (kg)	TSS (kg)
EPEA Approval Limit	Max Daily Avg./Month	80 kg/day	160 kg/day			160 kg/day			
	Maximum Daily	160 kg/day	320 kg/day	<400	6.0-9.5	270 kg/day			
Cargill (1997)[5]	Max.	26.9	86	103950	6.58	31.44			
	Min.	0.96	0.52	2.57	5.74	0.04			
	Avg.	9.5	33.2	11114	6.1	5.23	1,417,400	13,465	47,058

BOD_5 = biochemical oxygen demand, DO = dissolved oxygen, TSS = total suspended solids, Max/Min/Avg = monthly average values

Fec. Col. = Fecal Coliforms, Provincial Limit = not to exceed 400 mpn/100ml

(1) Canadian Water Quality Guidelines for the Protection of Aquatic Life

(2) Warm-water biota: early life stages= 6 mg/l, other life stages = 5 mg/l
Cold-water biota: early life stages = 9.5 mg/l, other life stages = 6.5 mg/l

(3) Thermal additions should not alter thermal stratification or turnover dates, exceed maximum weekly average temperatures, nor exceed maximum short-term temperatures.

(4) Plant upgrades in December, 1998 significantly improved water quality (expect 60% reductions in BOD and TSS). 6.7% used as irrigation water by D'Arcy Ranch Golf Course.

(5) Current upgrading is expected to be commissioned in June, 1999. Current wastewater contains approximately 28 mg/l phosphorus. Upgrading is expected to reduce phosphorus levels to the 5 to 10 mg/l range. Discharge is to Frank Lake in low runoff years or for alfalfa irrigation (Third Ranches Ltd.) in high runoff years.

(6) Total volumes are computed as annual flow times average annual concentration.

Table 11 - FACTORS AFFECTING POPULATION GROWTH IN THE STUDY AREA

Factor	*Effect in Parts of Study Area Close to Calgary**	*Effect in Parts of Study Area Far from Calgary**	*Scheduling/Other Comments*
Expansion of highway system, e.g. Deerfoot Trail extension, expansion of Hwy2A, Hwy 22 improvements	Very significant +	Moderate +	Deerfoot and Hwy 2A projects to be completed by 2002, will reduce driving time to Calgary appreciably
Expansion of regional highway system, especially North-South Trade Corridor	Moderate +	Significant +	Corridor will facilitate trade access to U.S. via Coutts; Hwy 22 likely to be promoted for tourist traffic
Establishment of suburban train service	Significant +	Slight +	Timetable unclear but fully expected in medium term, will aid study area's desirability for commuters and others seeking small town living
Development of a significant industrial node between Aldersyde and the Town of High River	Moderate +	Slight +	Growth is expected in the near term, but much will depend on the nature of the industries attracted to this location
Development policies of individual municipalities, e.g. re strategic planning and zoning	Significant + or -	Moderate + or - (in M.D. No.26 pro-agriculture policies likely)	Municipal councils will have considerable influence over the direction of development in their jurisdictions, esp. re country (non-farm) residential or via limits to growth of resident population
Further tourism and recreation development	Significant +	Moderate +	Further demand expected for golf, equestrian, water sports, campgrounds, agricultural society, back country, retreat & entertainment facilities and cabin/artificial lake developments; attempts will be made to build recreation facilities in association with the Little Bow Project reservoir
Growth of retail/service sector to accommodate increased population	Significant +	Slight +	There will be growth in retail and service businesses which can compete with commercial centres in the southern end of Calgary
Study area communities successful in portraying quality of life attractions relative to Calgary	Significant +	Moderate +	As congestion, pollution and crime increase in Calgary, or as perception of same increases, population and some small businesses will spill into the study area
Communities may choose to foster an image that portrays a particular quality of life	Moderate +	Moderate +	some communities will build a very particular public image, e.g Turner Valley as a place of artisans, craftspeople and recording artists
Study area communities successful in portraying attractions for industry relative to Calgary	Moderate +	Slight +	As the costs of doing business in Calgary increase, entrepreneurs will consider industrial land prices and other possible advantages of moving to the study area

Note* positive (+) and negative (-) are used here to refer to the expected relationship between study area population and the factor in question; they do not reflect a value judgment of the authors with respect to desirability or otherwise of the expected trend.

Table 11 (continued)

FACTORS AFFECTING POPULATION GROWTH IN THE STUDY AREA

Factor	*Effect in Parts of Study Area Close to Calgary**	*Effect in Parts of Study Area Far from Calgary**	*Scheduling/Other Comments*
Some inflow of retiree population from other Southern Alberta communities	Slight -	Slight -	Some communities will attract retirees from elsewhere in S. Alberta, especially if facilities for seniors are present, e.g. Vulcan, High River
Draw of city life and opportunities attracting young people	Moderate (and declining) -	Moderate -	The southern portions of the study area may continue to have difficulty keeping young people from leaving
Growth in intensive livestock operations	Slight as new operators will wish to avoid conflict with non-farm rural population. +	Moderate, possibly higher in M.D. No. 26 where zoning discourages non-farm rural population. +	Depends to large extent on provincial government standardization of regulations affecting siting and management of such operations
Further movement to larger and fewer farms	Negligible as some become acreages or hobby farms, No discern-able effect	Moderate w/ declining farm pop. In south of study area -	Longstanding trend reflecting structural characteristics of the agricultural sector, including greater value-chain management; current poor farm-gate prices for hogs and grains exacerbate the trend
Growth of irrigated agriculture	Negligible	Slight +	Expected to result from Little Bow Project once constructed, however food processing plants may not follow as such infrastructure is well developed in Lethbridge area
Further growth in usage of Internet and telecommunications	Significant +	Moderate /Slight +	Will encourage knowledge-based businesses and tele-commuting (e.g. employees of Calgary companies working portions of their time at home)
Uncertainty in oil and natural gas prices	Moderate (and declining), + or -	Slight (and declining), +or -	Petroleum prices, for decades the main driver of economic activity in Calgary, will become less influential as the economy continues to grow and diversify
Government policies with respect to implementation of the Kyoto Protocol	Uncertain as to outcomes	Uncertain as to outcomes	Governments may instigate more stringent pollution restrictions that could alter current vehicle ownership and usage patterns
Uncertainty in Canada's process of nation-building	Uncertain as to outcomes	Uncertain as to outcomes	Additional opportunities will arise for Quebec voters to indicate support for sovereignty

Note* positive (+) and negative (-) are used here to refer to the expected relationship between study area population and the factor in question; they do not reflect a value judgment of the authors with respect to desirability or otherwise of the expected trend.

Table 12 - COMPARISON OF RELEVANT POPULATION PROJECTIONS BY DIFFERENT AGENCIES

Calgary Regional Planning Commission Projection (prepared 1992 using 1991 federal census data)

					% change		
	1996	2001	2006	2011	2001/1996	2006/2001	2011/2006
City of Calgary (1991 federal census population of 710,680)							
Low Migration	770,022	822,465	868,638	911,720	6.8%	5.6%	5.0%
Medium Migration	786,894	857,976	924,578	989,500	9.0%	7.8%	7.0%
High Migration	797,439	880,171	959,540	1,038,112	10.4%	9.0%	8.2%
Town of High River (1991 federal census population of 6,280)							
Low Migration	6,652	7,026	7,419	7,829	5.6%	5.6%	5.5%
Medium Migration	7,437	8,598	9,765	10,945	15.6%	13.6%	12.1%
High Migration	7,958	9,642	11,324	13,016	21.2%	17.4%	14.9%
Town of Okotoks (1991 federal census population of 6,715)							
Low Migration	7,580	8,411	9,287	10,213	11.0%	10.4%	10.0%
Medium Migration	8,213	9,678	11,181	12,732	17.8%	15.5%	13.9%
High Migration	8,844	10,942	13,067	15,235	23.7%	19.4%	16.6%
M.D. of Foothills (1991 federal census population of 10,910)							
Low Migration	11,535	12,093	12,599	13,037	4.8%	4.2%	3.5%
Medium Migration	12,356	13,754	15,106	16,429	11.3%	9.8%	8.8%
High Migration	13,257	15,574	17,849	20,137	17.5%	14.6%	12.8%
Total HR,OK & MD 31 (1991 federal census population of 23,905)							
Low Migration	25,767	27,530	29,305	31,079	6.8%	6.4%	6.1%
Medium Migration	28,006	32,030	36,052	40,106	14.4%	12.6%	11.2%
High Migration	30,059	36,158	42,240	48,388	20.3%	16.8%	14.6%

Source: Calgary Regional Planning Comission, Prospect: Population Projections for the Calgary Region, March 1993

Alberta Treasury Projection

Census Division 6					% change		
	1996	2001	2006	2011	2001/1996	2006/2001	2011/2006
Low Projection	894,675	953,605	1,006,830	1,050,710	6.6%	5.6%	4.4%
Medium Projection	898,935	965,925	1,032,425	1,092,585	7.5%	6.9%	5.8%
High Projection	900,180	974,225	1,047,305	1,118,865	8.2%	7.5%	6.8%

Source: Alberta Treasury, Alberta Population Projections Census Divisions 1995-2011, May 1997

Alberta Health Projection

Headwaters Health Authority						% change			
	1996	2001	2006	2011	2016	2001/1996	2006/2001	2011/2006	2016/2011
Projection	69,116	76,883	85,070	93,485	101,958	11.2%	10.6%	9.9%	9.1%

Source: Alberta Health, Population Projections for Alberta and its Health Regions 1996-2016, March 1998

City of Calgary Finance Dept. Projection

City of Calgary								% change			
	1996	2001	2006	2011	2016	2021	2026	2001/1996	2006/2001	2011/2006	2016/2011
Projection	767,059	893,653	981,650	1,085,729	1,203,753	1,333,088	1,467,776	16.5%	9.8%	10.6%	10.9%
										2021/2016	2026/2021
										10.7%	10.1%

Source: City of Calgary Finance Dept., The Calgary Economic Outlook 1998 through 2003, November 1998

Table 13 - PROJECTED POPULATION BY RIVER BASIN AND MUNICIPALITY - LOW GROWTH CASE

	1981 Census	1986 Census	1991 Census	1996 Census	2001 Proj.	2006 Proj.	2011 Proj.	2016 Proj.	2021 Proj.	2026 Proj.	2031 Proj.	2036 Proj.	2041 Proj.	2046 Proj.
SHEEP RIVER BASIN														
Okotoks	3,847	5,214	6,723	8,510	10,006	11,501	12,807	14,141	15,860	17,781	19,928	22,327	25,003	27,990
Black Diamond	1,444	1,486	1,623	1,811	1,984	2,145	2,279	2,420	2,584	2,758	2,942	3,138	3,345	3,566
Turner Valley	1,311	1,271	1,352	1,527	1,709	1,851	1,972	2,093	2,237	2,392	2,555	2,729	2,913	3,110
Rural (59% of MD 31)	5,674	5,513	6,399	8,045	9,449	10,478	11,313	12,113	13,150	14,270	15,481	16,787	18,200	19,722
Sub-total	12,276	13,484	16,097	19,893	23,148	25,975	28,371	30,767	33,831	37,201	40,906	44,981	49,461	54,388
% increase over 5 years		9.8%	19.4%	23.6%	16.4%	12.2%	9.2%	8.4%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
HIGHWOOD RIVER BASIN														
High River	4,845	5,096	6,269	7,359	8,283	8,919	9,426	9,894	10,490	11,115	11,774	12,468	13,194	13,955
Longview	301	276	271	303	318	331	352	372	391	410	434	455	481	504
Eden Valley Reserve	353	432	370	432	515	604	700	798	921	1,065	1,234	1,424	1,642	1,895
Rural (25% of MD 31)	2,432	2,363	2,743	3,448	4,050	4,491	4,848	5,191	5,638	6,120	6,632	7,189	7,789	8,435
Sub-total	7,931	8,167	9,853	11,542	13,166	14,345	15,326	16,255	17,440	18,710	20,074	21,536	23,106	24,789
% increase over 5 years		3.0%	18.2%	19.6%	14.1%	9.0%	6.8%	6.1%	7.3%	7.3%	7.3%	7.3%	7.3%	7.3%
MOSQUITO CREEK BASIN														
Nanton	1,641	1,562	1,589	1,665	1,740	1,787	1,823	1,861	1,902	1,943	1,985	2,027	2,068	2,112
Rural (15.5% of MD 26)(ii)	702	734	738	793	838	877	927	979	1,031	1,086	1,144	1,204	1,269	1,335
Sub-total	2,343	2,296	2,327	2,458	2,578	2,664	2,750	2,840	2,933	3,029	3,129	3,231	3,337	3,447
% increase over 5 years		-2.0%	1.4%	5.6%	4.9%	3.3%	3.2%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%
UPPER LITTLE BOW BASIN														
Vulcan	1,495	1,420	1,466	1,537	1,663	1,707	1,781	1,869	1,943	2,020	2,100	2,184	2,270	2,360
Rural (5% of County 2)	185	183	182	191	202	212	224	236	249	262	276	290	306	322
Sub-total	1,680	1,603	1,648	1,728	1,865	1,919	2,005	2,105	2,192	2,282	2,376	2,474	2,576	2,682
% increase over 5 years		-4.6%	2.8%	4.9%	7.9%	2.9%	4.5%	5.0%	4.1%	4.1%	4.1%	4.1%	4.1%	4.1%
Total	24,229	25,550	29,725	35,620	40,757	44,902	48,452	51,967	56,396	61,223	66,485	72,222	78,480	85,306
% increase over 5 years		5.4%	16.3%	19.8%	14.4%	10.2%	7.9%	7.3%	8.5%	8.6%	8.6%	8.6%	8.7%	8.7%

Notes:

(I) Based on Statistics Canada projections to the year 2016; subsequent years are calculated on a straight-line basis according to the average of the three five-year growth rates covering the 2001-2016 period.

(ii) In the absence of a Statistics Canada projection for MD # 26, growth for the portion of MD # 26 lying inside the study area was assumed to be equal to that for County # 2.

Table 14 - PROJECTED POPULATION BY RIVER BASIN AND MUNICIPALITY - MEDIUM GROWTH CASE

	1996 Census	2001 Proj.	2006 Proj.	2011 Proj.	2016 Proj.	2021 Proj.	2026 Proj.	2031 Proj.	2036 Proj.	2041 Proj.	2046 Proj.
SHEEP RIVER BASIN											
Okotoks	8,510	10,156	11,825	13,300	14,824	16,803	19,018	21,520	24,343	27,525	31,115
Black Diamond	1,811	2,001	2,180	2,330	2,487	2,670	2,880	3,103	3,340	3,595	3,868
Turner Valley	1,527	1,727	1,885	2,020	2,156	2,320	2,505	2,700	2,909	3,134	3,375
Rural (59% of MD 31)	8,045	9,589	10,737	11,678	12,586	13,772	15,059	16,462	17,990	19,651	21,453
Sub-total	**19,893**	**23,473**	**26,627**	**29,328**	**32,053**	**35,565**	**39,462**	**43,785**	**48,582**	**53,905**	**59,811**
% increase over 5 years		18.0%	13.4%	10.1%	9.3%	11.0%	11.0%	11.0%	11.0%	11.0%	11.0%
HIGHWOOD RIVER BASIN											
High River	7,359	8,375	9,083	9,650	10,176	10,848	11,565	12,322	13,120	13,962	14,850
Longview	303	320	334	357	379	402	430	457	486	517	551
Eden Valley Reserve	432	523	623	732	844	989	1,165	1,357	1,586	1,856	2,167
Rural (25% of MD 31)	3,448	4,110	4,602	5,004	5,394	5,900	6,432	7,026	7,667	8,356	9,102
Sub-total	**11,542**	**13,328**	**14,641**	**15,743**	**16,793**	**18,139**	**19,592**	**21,163**	**22,859**	**24,691**	**26,670**
% increase over 5 years		15.5%	9.9%	7.5%	6.7%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%
MOSQUITO CREEK BASIN											
Nanton	1,665	1,748	1,799	1,839	1,881	1,927	1,972	2,017	2,063	2,109	2,156
Rural (15.5% of MD 26)(ii)	793	842	886	941	999	1,057	1,220	1,187	1,256	1,330	1,407
Sub-total	**2,458**	**2,590**	**2,685**	**2,780**	**2,880**	**2,984**	**3,092**	**3,204**	**3,319**	**3,439**	**3,563**
% increase over 5 years		5.4%	3.7%	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%	3.6%
UPPER LITTLE BOW BASIN											
Vulcan	1,537	1,676	1,724	1,807	1,905	1,988	2,078	2,168	2,263	2,361	2,466
Rural (5% of County 2)	191	203	214	227	241	255	267	283	299	317	334
Sub-total	**1,728**	**1,879**	**1,939**	**2,034**	**2,146**	**2,243**	**2,345**	**2,451**	**2,562**	**2,678**	**2,800**
% increase over 5 years		8.7%	3.2%	4.9%	5.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%
Total	**35,620**	**41,270**	**45,891**	**49,886**	**53,872**	**58,931**	**64,491**	**70,602**	**77,323**	**84,714**	**92,844**
% increase over 5 years		15.9%	11.2%	8.7%	8.0%	9.4%	9.4%	9.5%	9.5%	9.6%	9.6%

Notes:

(I) Based on a 10% increase in the five-year growth rates for the years 1996-2016 over the Statistics Canada projections (from Table 13); data following 2016 are calculated on a straight-line basis according to the average of the three five-year growth rates covering the 2001-2016 period.

(ii) In the absence of a Statistics Canada projection for MD # 26, growth for the portion of MD # 26 lying inside the study area was assumed to be equal to that for County # 2.

Table 15 - PROJECTED POPULATION BY RIVER BASIN AND MUNICIPALITY - HIGH GROWTH CASE

	1996 Census	2001 Proj.	2006 Proj.	2011 Proj.	2016 Proj.	2021 Proj.	2026 Proj.	2031 Proj.	2036 Proj.	2041 Proj.	2046 Proj.
SHEEP RIVER BASIN											
Okotoks	8,510	10,305	12,152	13,807	15,530	17,790	20,344	23,257	26,582	30,365	34,670
Black Diamond	1,811	2,019	2,215	2,380	2,556	2,763	2,998	3,251	3,520	3,813	4,126
Turner Valley	1,527	1,745	1,919	2,069	2,221	2,405	2,612	2,835	3,074	3,332	3,610
Rural (59% of MD 31)	8,045	9,730	11,001	12,051	13,071	14,410	15,880	17,492	19,257	21,190	23,310
Sub-total	**19,893**	**23,799**	**27,287**	**30,307**	**33,378**	**37,368**	**41,834**	**46,835**	**52,433**	**58,700**	**65,716**
% increase over 5 years		19.6%	14.7%	11.1%	10.1%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%
HIGHWOOD RIVER BASIN											
High River	7,359	8,468	9,247	9,876	10,463	11,215	12,018	12,877	13,780	14,740	15,752
Longview	303	321	337	362	386	411	442	472	505	540	578
Eden Valley Reserve	432	532	642	764	892	1,059	1,260	1,490	1,765	2,090	2,474
Rural (25% of MD 31)	3,448	4,170	4,714	5,165	5,602	6,174	6,788	7,463	8,202	9,002	9,874
Sub-total	**11,542**	**13,490**	**14,940**	**16,167**	**17,343**	**18,859**	**20,508**	**22,302**	**24,252**	**26,372**	**28,678**
% increase over 5 years		16.9%	10.7%	8.2%	7.3%	8.7%	8.7%	8.7%	8.7%	8.7%	8.7%
MOSQUITO CREEK BASIN											
Nanton	1,665	1,755	1,812	1,856	1,901	1,952	2,001	2,050	2,100	2,151	2,200
Rural (15.5% of MD 26)(ii)	793	847	894	955	1,020	1,084	1,155	1,230	1,309	1,392	1,483
Sub-total	**2,458**	**2,602**	**2,706**	**2,811**	**2,921**	**3,036**	**3,156**	**3,280**	**3,409**	**3,543**	**3,683**
% increase over 5 years		5.9%	4.0%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%
UPPER LITTLE BOW BASIN											
Vulcan	1,537	1,688	1,742	1,832	1,941	2,034	2,131	2,234	2,340	2,452	2,570
Rural (5% of County 2)	191	204	216	231	246	262	278	294	313	332	352
Sub-total	**1,728**	**1,892**	**1,958**	**2,063**	**2,187**	**2,295**	**2,409**	**2,528**	**2,653**	**2,784**	**2,922**
% increase over 5 years		9.5%	3.5%	5.4%	6.0%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%
Total	**35,620**	**41,784**	**46,891**	**51,348**	**55,830**	**61,559**	**67,907**	**74,944**	**82,746**	**91,399**	**100,998**
% increase over 5 years		17.3%	12.2%	9.5%	8.7%	10.3%	10.3%	10.4%	10.4%	10.5%	10.5%

Notes:

(i) Based on a 20% increase in the five-year growth rates for the years 1996-2016 over the Statistics Canada projections (in Table 13); data following 2016 are calculated on a straight-line basis according to the average of the three five-year growth rates covering the 2001-2016 period.

(ii) In the absence of a Statistics Canada projection for MD # 26, growth for the portion of MD # 26 lying inside the study area was assumed to be equal to that for County # 2.

Table 16 - PROJECTED HIGH, MEDIUM AND LOW LICENCED WATER WITHDRAWALS AND AVERAGE WITHDRAWAL PER CAPITA IN THE STUDY AREA - YEAR 2021

	SHEEP	HIGHWOOD	MOSQUITO	LITTLE BOW	TOTAL (DAM^3)	TOTAL (m^3)/Capita
2021 - Low Case Licenced Water Withdrawals (DAM^3)						
Stockwatering	1003	2013	1154	472	4642	82
Other Non-Irrig.Agricultural	606	568	188	0	1361	24
Municipal	5127	3326	951	521	9926	176
Industrial	2779	4911	220	47	7956	141
Rural Domestic (Unlicenced)	1097	417	76	19	1609	29
Total	**10613**	**11234**	**2589**	**1058**	**25494**	**452**
2021 - Medium Case Licenced Water Withdrawals (DAM^3)						
Stockwatering	1094	2196	1259	515	5064	86
Other Non-Irrig.Agricultural	728	681	225	0	1634	28
Municipal	5690	3652	1022	562	10926	185
Industrial	2921	5587	223	48	8780	149
Rural Domestic (Unlicenced)	1153	434	78	19	1684	29
Total	**11586**	**12550**	**2807**	**1145**	**28087**	**477**
2021 - High Case Licenced Water Withdrawals (DAM^3)						
Stockwatering	1186	2379	1364	558	5486	89
Other Non-Irrig.Agricultural	849	795	263	0	1906	31
Municipal	6293	3997	1094	606	11989	195
Industrial	3069	6769	227	49	10115	164
Rural Domestic (Unlicenced)	1212	451	79	20	1762	29
Total	**12608**	**14391**	**3027**	**1232**	**31258**	**508**

Assumptions:

1. Stockwatering: increased 10%, 20% and 30% over current year (low, medium and high, respectively)
2. Other Agricultural: increased 25%, 50% and 75% over current year (low, medium and high, respectively)
3. Municipal: current per capita withdrawal/consumption rate reduced by 10%, 5% and 0%.
4. Industrial: current per capita withdrawal/consumption rate and addition of one industrial user with 1,000 dam^3/year of withdrawal and 400 dam^3/year of consumptive use. (500 dam^3 as low withdrawal and 2000 as high)
5. Rural Domestic: assume current per capita consumption -constant for all cases.
6. Withdrawals from the Highwood River for Frank Lake stabilization are not shown. Effluent from the Town of High River and Cargill plus new industry by year 2021 is projected at 4674 dam^3 for the medium case.

Table 17 - PROJECTED HIGH, MEDIUM AND LOW CONSUMPTIVE USE AND AVERAGE PER CAPITA USE IN THE STUDY AREA YEAR 2021

	SHEEP	HIGHWOOD	MOSQUITO	LITTLE BOW	TOTAL (DAM^3)	TOTAL (m^3)/Capita
2021 - Low Case Consumptive Use (DAM^3)						
Stockwatering	1003	2013	1154	472	4642	82
Other Non-Irrig.Agricultural	303	284	94	0	681	12
Municipal	886	1719	107	397	3110	55
Industrial	1945	2088	23	33	4089	73
Rural Domestic (Unlicenced)	1097	417	76	19	1609	29
Total	**5235**	**6521**	**1455**	**921**	**14131**	**251**
2021 - Medium Case Actual Consumptive Use (DAM^3)						
Stockwatering	1094	2196	1259	515	5064	86
Other Non-Irrig.Agricultural	364	341	113	0	817	14
Municipal	983	1887	115	429	3415	58
Industrial	2045	2364	24	34	4466	76
Rural Domestic (Unlicenced)	1153	434	78	19	1684	29
Total	**5640**	**7221**	**1588**	**997**	**15446**	**262**
2021 - High Case Actual Consumptive Use (DAM^3)						
Stockwatering	1186	2379	1364	558	5486	89
Other Non-Irrig.Agricultural	424	397	131	0	953	15
Municipal	1088	2065	124	462	3739	61
Industrial	2149	2842	24	34	5049	82
Rural Domestic (Unlicenced)	1212	451	79	20	1762	29
Total	**6058**	**8134**	**1722**	**1074**	**16988**	**276**

Assumptions as indicated in Table 16.
Withdrawals from the Highwood River and effluent from High River and industrial wastewater plants to Frank Lake in the Little Bow are not included in the above numbers.

Table 18 - PROJECTED HIGH, MEDIUM AND LOW LICENCED WATER WITHDRAWALS AND AVERAGE WITHDRAWAL PER CAPITA IN THE STUDY AREA - YEAR 2046

	SHEEP	HIGHWOOD	MOSQUITO	LITTLE BOW	TOTAL (DAM^3)	TOTAL (m^3)/Capita
2046 - Low Case Licenced Water Withdrawals (DAM^3)						
Stockwatering	1053	2114	1212	495	4874	57
Other Non-Irrig.Agric.	728	681	225	0	1634	19
Municipal	8060	4623	1093	623	14399	169
Industrial	4467	7269	258	57	12052	141
Rural Domestic (Unlicenced)	1763	593	90	23	2469	29
Total	**16072**	**15280**	**2878**	**1199**	**35428**	**415**
2046 - Medium Case Licenced Water Withdrawals (DAM^3)						
Stockwatering	1204	2416	1385	566	5570	60
Other Non-Irrig.Agric.	946	885	293	0	2124	23
Municipal	9329	5235	1190	684	16439	177
Industrial	4913	8745	267	60	13984	151
Rural Domestic (Unlicenced)	1939	638	93	24	2694	29
Total	**18331**	**17919**	**3226**	**1335**	**40811**	**440**
2046 - High Case Licenced Water Withdrawals (DAM^3)						
Stockwatering	1363	2736	1568	641	6309	62
Other Non-Irrig.Agric.	1188	1112	368	0	2668	26
Municipal	11067	6077	1328	771	19243	191
Industrial	5398	11253	276	63	16989	168
Rural Domestic (Unlicenced)	2131	686	96	25	2938	29
Total	**21147**	**21864**	**3635**	**1500**	**48146**	**477**

Assumptions

1. Stockwatering: increased 5, 10 and 15% over 2021 low, medium and high projected cases, respectively.
2. Other Agricultural: increased 20, 30 and 40% over 2021 low, medium and high projected cases, respectively.
3. Municipal: current per capita withdrawal rate reduced by 12%, 7.375% (2.5% from 2021) and 0%.
4. Industrial: current per capita withdrawal/consumption rate and addition of two industrial users with 1,000 dam^3/year of withdrawal and 400 dam^3/year of consumptive use (1000 dam^3 as low withdrawal and 4000 high).
5. Rural Domestic: assume current per capita consumption rate - constant for all cases.
6. Withdrawals from the Highwood River for Frank Lake stabilization are not shown. Effluent from the town of High River and Cargill plus new industry by the year 2046 is projected at 7122 dam^3 for the medium case.

Table 19 - PROJECTED HIGH, MEDIUM AND LOW CONSUMPTIVE USE AND AVERAGE PER CAPITA USE IN THE STUDY AREA YEAR 2046

	SHEEP	HIGHWOOD	MOSQUITO	LITTLE BOW	TOTAL (DAM^3)	TOTAL (m^3)/Capita
2046 - Low Case Actual Consumptive Use (DAM^3)						
Stockwatering	1053	2114	1212	495	4874	57
Other Non-Irrig.Agric.	364	341	113	0	817	10
Municipal	1393	2389	123	475	4381	51
Industrial	3127	3084	27	40	6278	74
Rural Domestic (Unlicenced)	1763	593	90	23	2469	29
Total	**7701**	**8519**	**1565**	**1034**	**18819**	**221**
2046 - Medium Case Actual Consumptive Use (DAM^3)						
Stockwatering	1204	2416	1385	566	5570	60
Other Non-Irrig.Agric.	473	443	146	0	1062	11
Municipal	1612	2705	134	522	4974	54
Industrial	3439	3687	28	42	7197	78
Rural Domestic (Unlicenced)	1939	638	93	24	2694	29
Total	**8667**	**9889**	**1786**	**1155**	**21497**	**232**
2046 - High Case Actual Consumptive Use (DAM^3)						
Stockwatering	1363	2736	1568	641	6309	62
Other Non-Irrig.Agric.	594	556	184	0	1334	13
Municipal	1913	3141	150	588	5792	57
Industrial	3779	4705	29	44	8556	85
Rural Domestic (Unlicenced)	2131	686	96	25	2938	29
Total	**9780**	**11823**	**2027**	**1299**	**24929**	**247**

Assumptions as per Table 18.
Withdrawals from the Highwood River and effluent from High River and industrial wastewater plants to Frank Lake in the Little Bow are not included in the above numbers.

Table 20 - SUMMARY OF STUDY AREA PROJECTIONS WITH SENSITIVITIES

Category	Year				
	Current (1996)	2021		2046	
		Projection	Sensitivity (%)	Projection	Sensitivity (%)
Population	35,620	58,931	-4.5 to +4.5	92,844	-8.8 to +8.8
Withdrawal (dam^3)	18,507	28,087	-10.2 to +11.3	40,811	-15.2 to +18.0
Consumptive Use (dam^3)	10,780	15,446	-9.3 to +10.0	21,497	-14.2 to +16.0
Return Flow (dam^3)	7,727	12,642	-11.2 to +12.9	19,314	-16.3 to +20.2

Note: Return flow = Withdrawal - Consumptive Use (including losses)

In the current year, 2292 dam^3 of the return flow above plus 286 dam^3 of the withdrawals and consumptive use above is assumed to be diverted from the Highwood River to Frank Lake. Withdrawals from the Highwood River to Frank Lake are not included in the totals above in years 2021 and 2046.

Table 21 - PROJECTED TREATMENT PLANT RETURN FLOW EFFLUENT LOADINGS BY SUB-BASIN

Sub-Basin	Current Year			Year 2021			Year 2046		
	Flow (dam^3/yr)	BOD (kg/yr)	TSS (kg/yr)	Flow (dam^3/yr)	BOD (kg/yr)	TSS (kg/yr)	Flow (dam^3/yr)	BOD (kg/yr)	TSS (kg/yr)
Sheep	2182	23040	22140	3720	19400	17800	6080	31700	29100
% change over current yr.				70.5%	-15.8%	-19.6%	178.6%	37.6%	31.4%
Highwood									
Longview	80	334	661	120	500	990	170	710	1400
High River	1237	7547	10516	1850	11260	15700	2650	16150	22500
Industrial	1417	13465	47058	2830	26800	33800	4470	42500	53000
Highwood Sub-total	2734	21346	58235	4800	38560	50490	7290	59360	76900
% change over current yr.				75.6%	80.6%	-13.3%	166.6%	178.1%	32.1%
Mosquito	251	1501	2107	290	1735	2435	340	2020	2840
% change over current yr.				15.5%	15.6%	15.6%	35.5%	34.6%	34.8%
Little Bow	-	-	-	-	-	-	-	-	-
Frank Lake Stabilization	2466 dam^3/yr comes from a combination of High River and Industrial plant wastewater from Highwood.								
TOTAL	5167	45887	82482	8810	59695	70725	13710	93080	108840
% change over current yr.				70.5%	30.1%	-14.3%	165.3%	102.8%	32.0%

Assumptions: 1. Sheep Basin: Okotoks plant is upgraded providing 60% improvement in removals in yr. 2021 and 2046. 6.7% of total effluent at Okotoks is used for irrigation. No changes to Westend Plant.

2. Highwood: Longview and High River - no system changes. Industrial growth as per medium case growth assumptions (all new major industry effluent is included here) with BOD loadings as per current Cargill conditions and TSS loadings reduced by 64% (i.e. 28 mg/l to 10 mg/l as per phosphorous reductions) in Years 2021 and 2046. Industrial and High River effluent irrigation occurs and will likely increase in the future - amounts are not estimated here.

3. Mosquito: only return flow is from Nanton - no system changes.

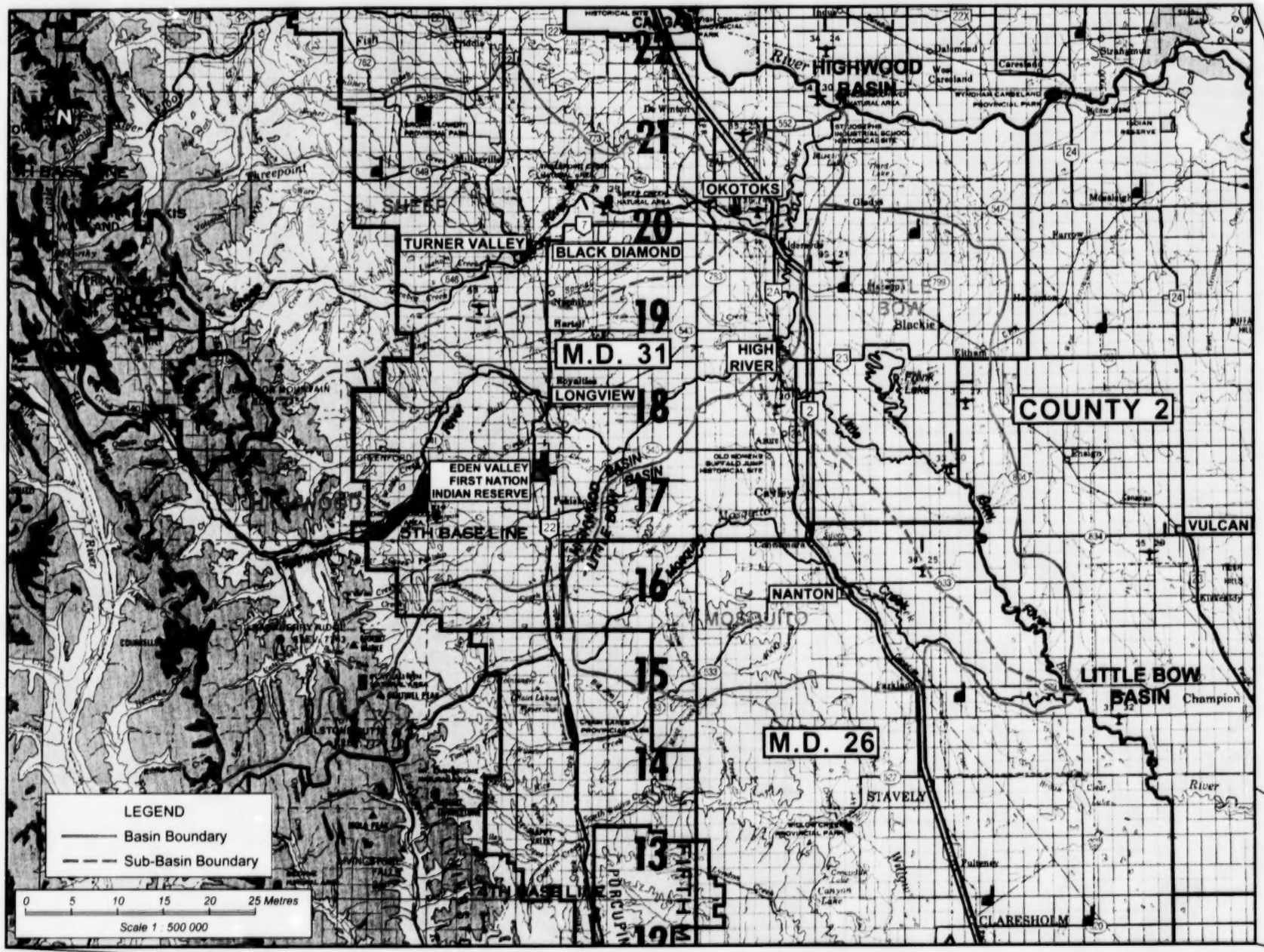
4. Little Bow: no plant return flows. Frank Lake receives industrial and High River effluent as noted.

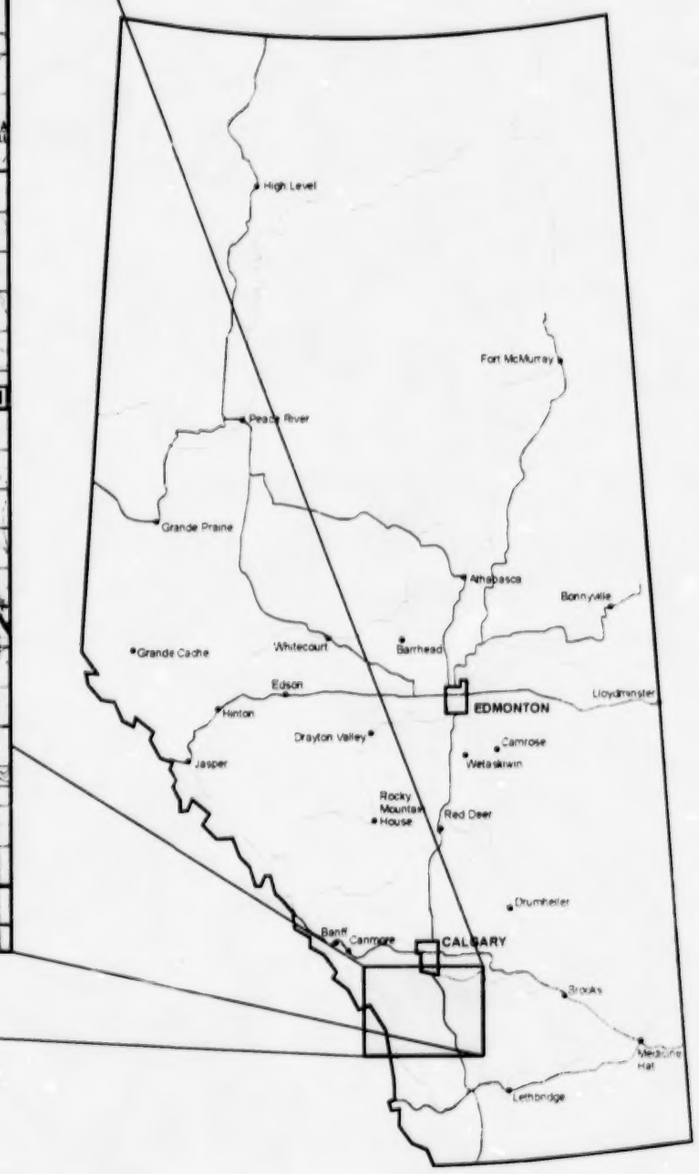
5. Return flows estimated as per medium case growth assumptions.

Non-Irrigation Consumptive Demand Projections
Little Bow Project EIA

Map of Study Area

Figure 1





DRAWN	Gary Evenson
DESIGN	Paul Cox
APP	Dave Cooper
DATE	99/03/12
FILE	371-A2 CDR

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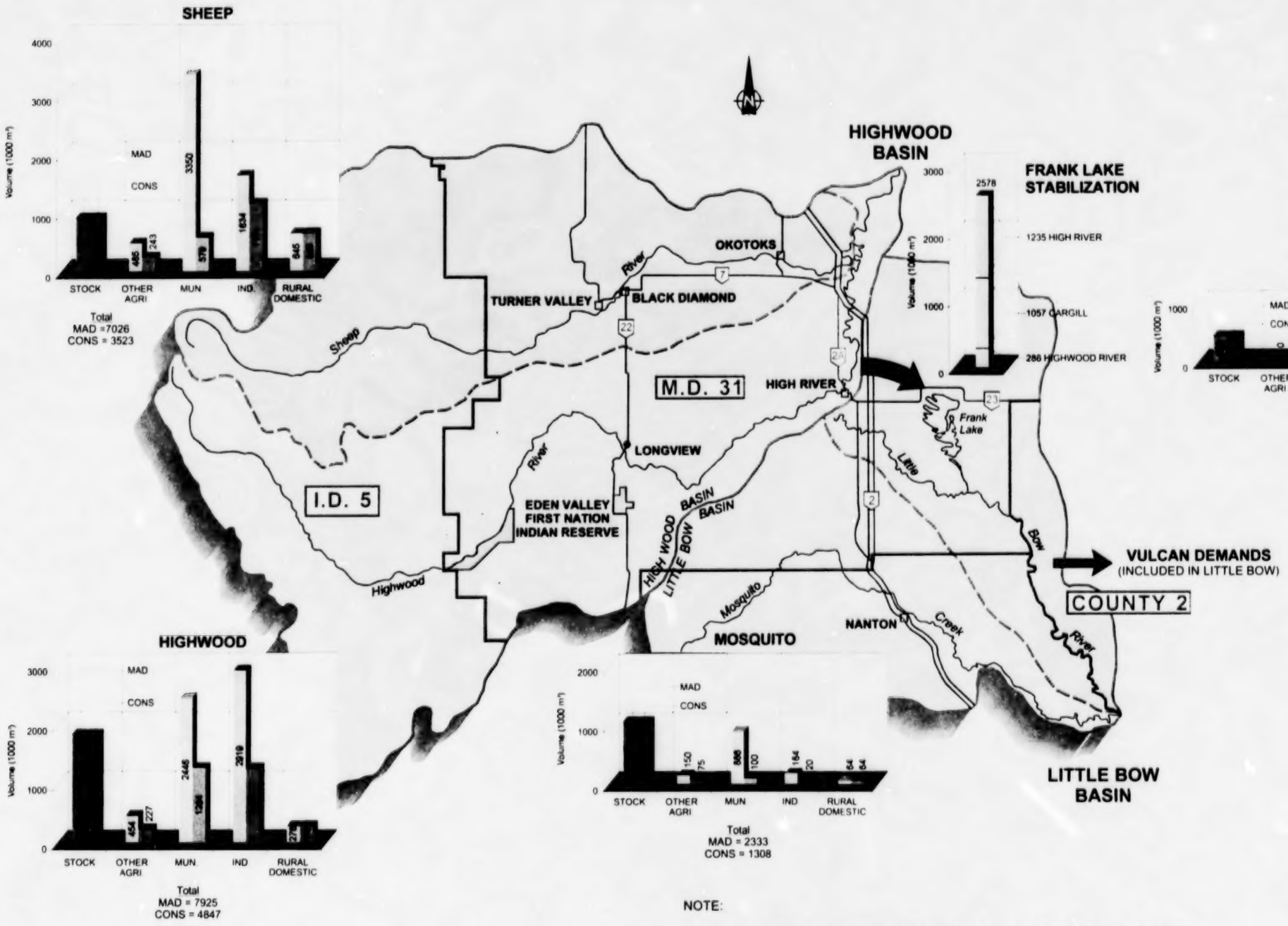
Worldwide Resource Economics

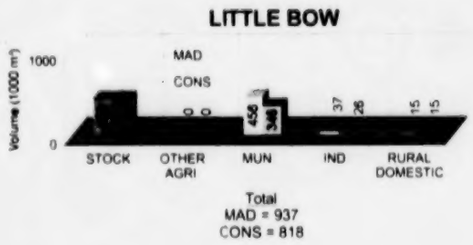
PREPARED FOR
Alberta ENVIRONMENT

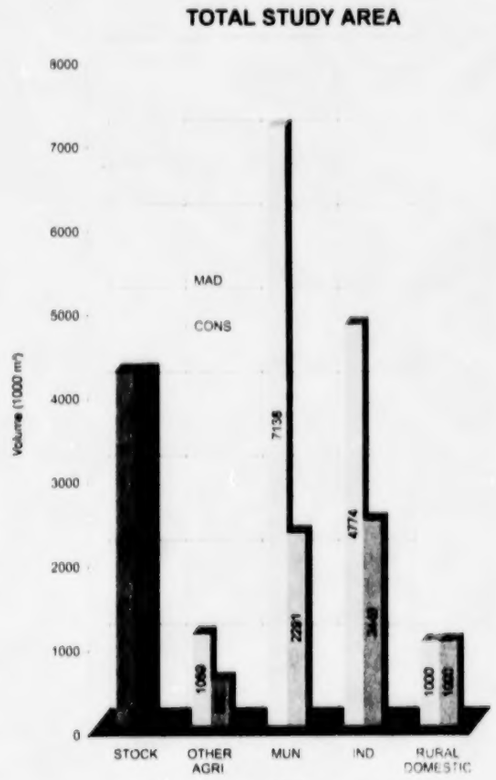
Non-Irrigation Consumptive Demand Projections
Little Bow Project EIA

Current Withdrawal and Estimated Consumptive Use by Type of Use

Figure 2







NOTE:

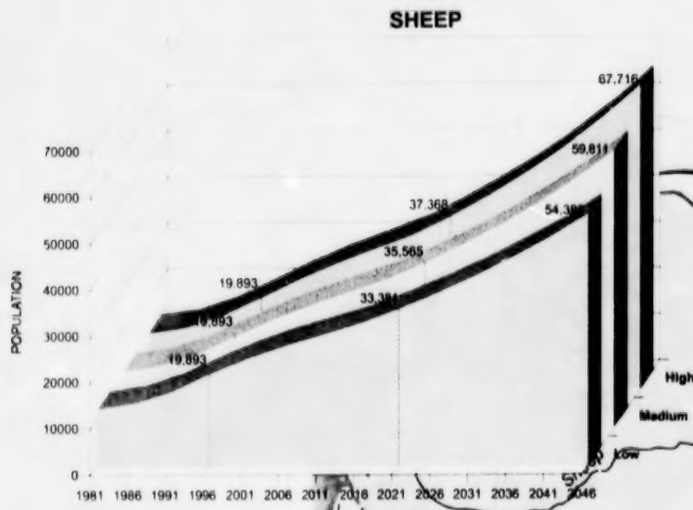
1. Based on estimated Consumptive Use (CONS) and Mean Annual Diversion (MAD) or withdrawals from licences, as detailed in Table 8.
2. CONS includes losses (evaporation, seepage, etc.).
3. Municipal denotes licences held by towns and villages and related uses including: schools, recreation centres, fire protection, sub-divisions, co-operatives and colonies.
4. All values shown are in 1000 m³ (dam³).
5. Frank Lake stabilization flows are separated out as shown.

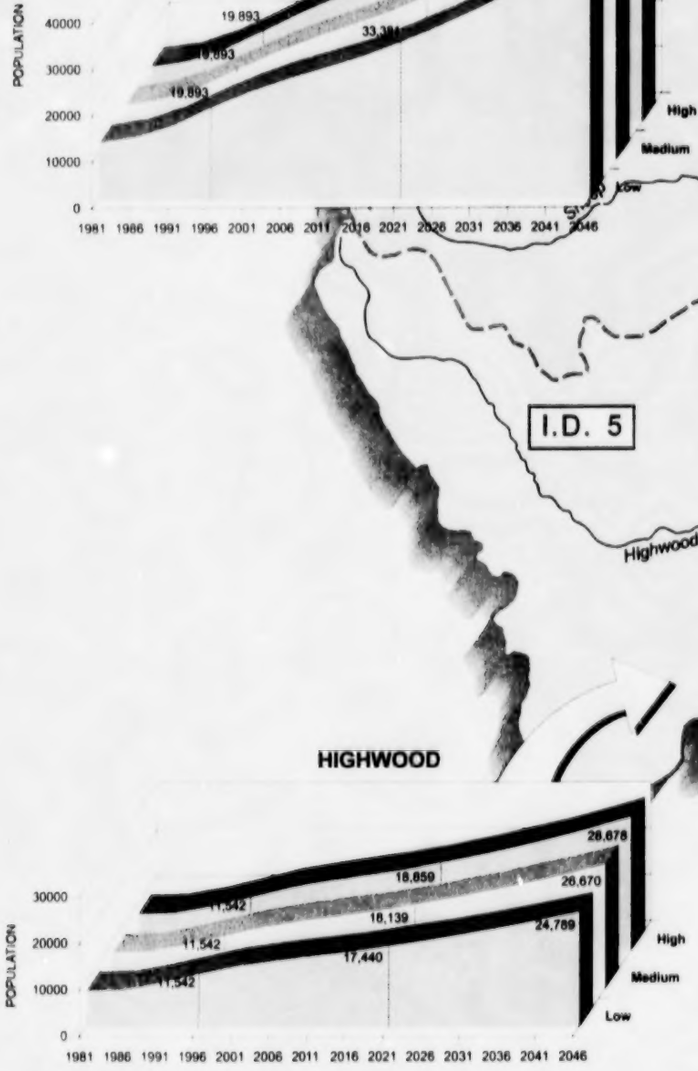
DRAWN: Gary Evenson DESIGN: Paul Cox APP: Dave Cooper DATE: 99/03/12 FILE: 371-A3.CDR	PREPARED BY: Hydroconsult; Worldwide Resource Economics	PREPARED FOR: Alberta Environment

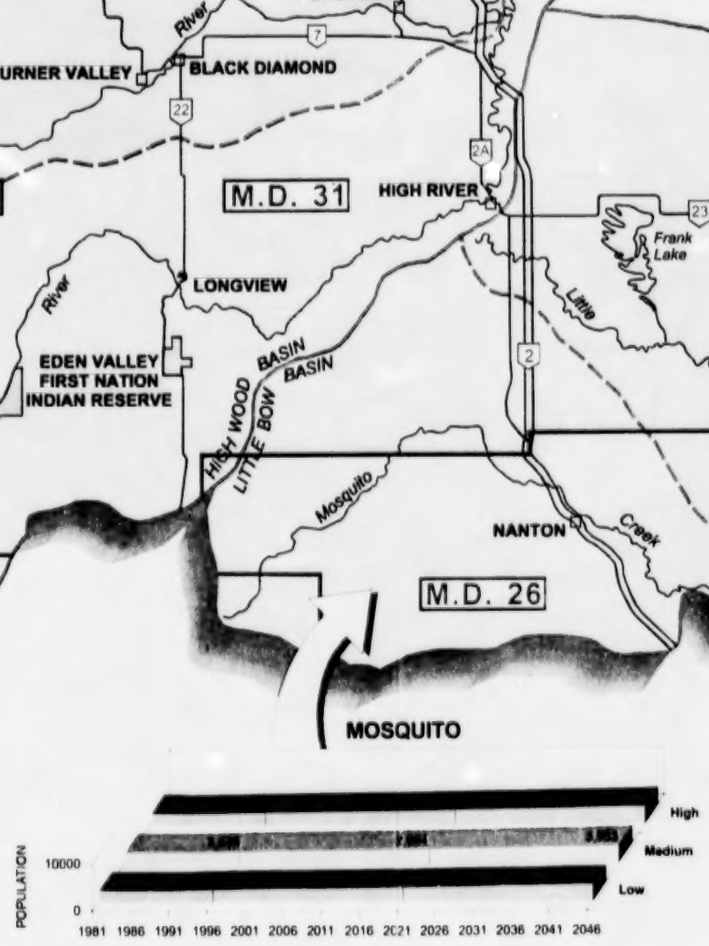
Non-Irrigation Consumptive Demand Projections
Little Bow Project EIA

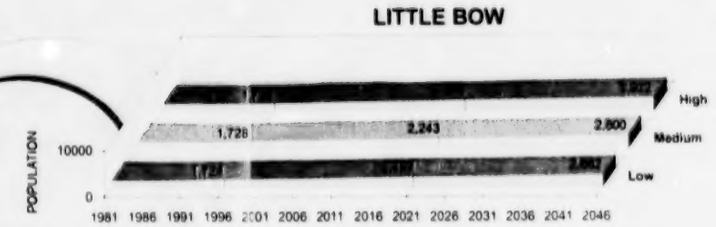
Historical and Projected Population

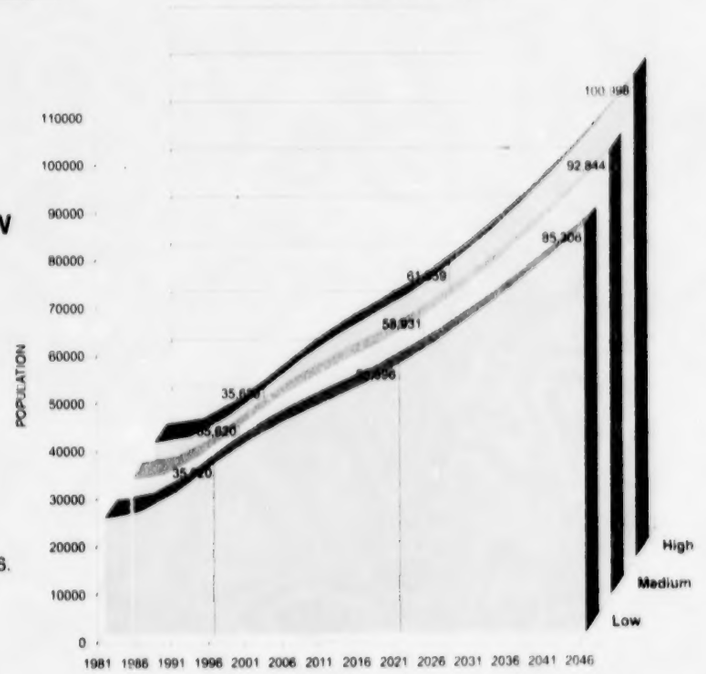
Figure 3











NOTE:

1. 1981 to 1996 Data are based on Statistics Canada Censuses.
2. 1996 to 2016 Data are based on Statistics Canada customized projections to the year 2016.
   - Low Case utilizes Statistics Canada assumptions.
   - Medium case utilizes Statistics Canada growth rates increased by 10%.
   - High Case utilizes Statistics Canada growth rates increased by 20%.
3. 2016 to 2046 Data are based on the average growth rate from 2001-2016 for each case.

DRAWN	Gary Evenson
DESIGN	Paul Cox
APP	Dave Cooper
DATE	99/03/12
FILE	371-A3 CDR

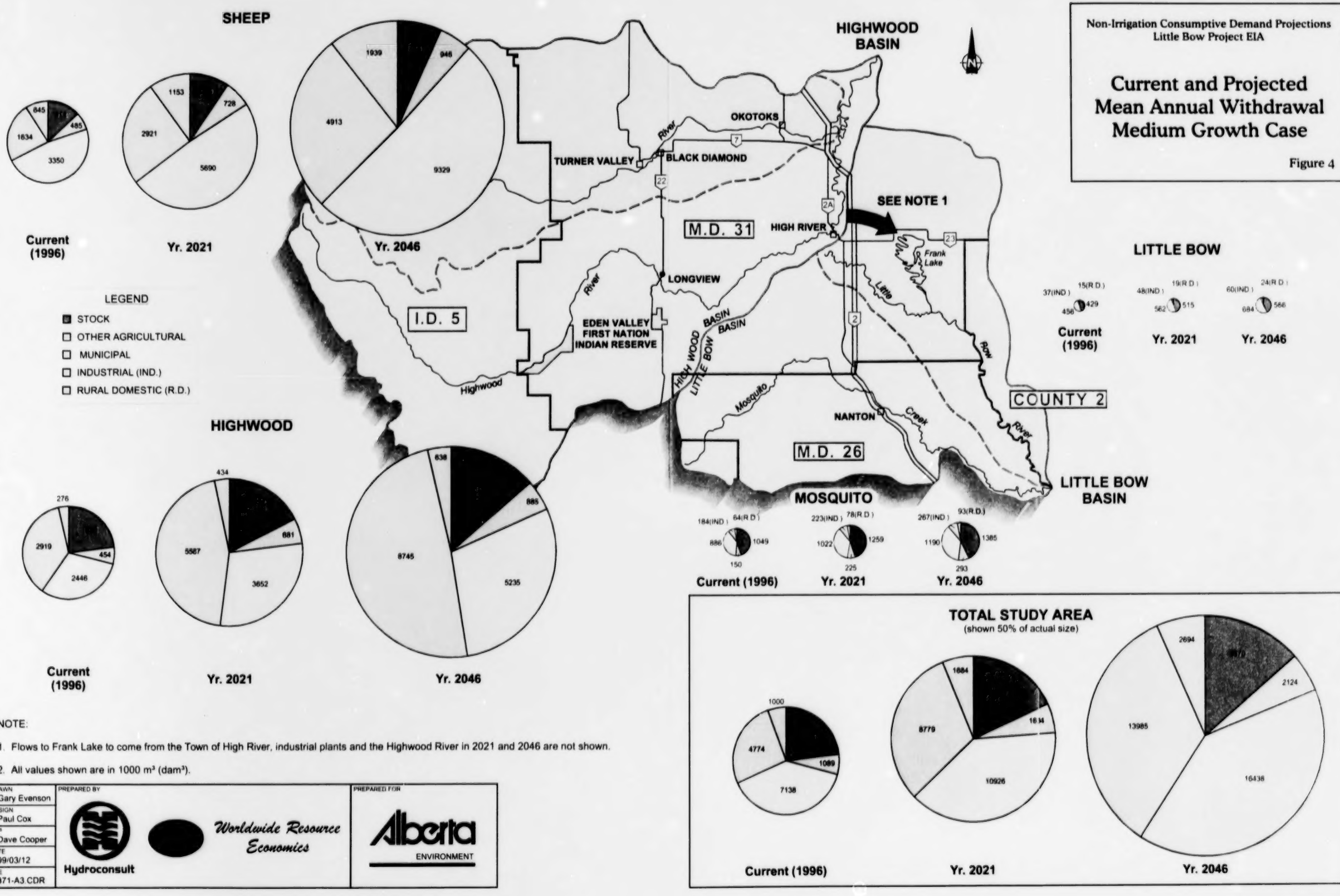
PREPARED BY: Hydroconsult; Worldwide Resource Economies

PREPARED FOR: Alberta Environment

Non-Irrigation Consumptive Demand Projections
Little Bow Project EIA

Current and Projected Mean Annual Withdrawal Medium Growth Case

Figure 4



NOTE:

1. Flows to Frank Lake to come from the Town of High River, industrial plants and the Highwood River in 2021 and 2046 are not shown.
2. All values shown are in 1000 m^3 (dam^3).

DRAWN	Gary Evenson
DESIGN	Paul Cox
APP	Dave Cooper
DATE	99/03/12
FILE	371-A3.CDR

PREPARED BY: Hydroconsult; Worldwide Resource Economics

PREPARED FOR: Alberta Environment

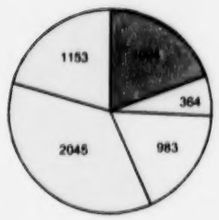
Non-Irrigation Consumptive Demand Projections
Little Bow Project EIA

Current and Projected Consumptive Use - Medium Growth Case

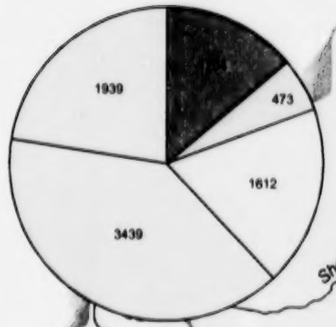
Figure 5

SHEEP

Current (1996)



Yr. 2021



Yr. 2046

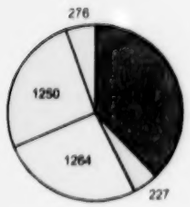
LEGEND

- STOCK
- OTHER AGRICULTURAL
- MUNICIPAL
- INDUSTRIAL (IND.)
- RURAL DOMESTIC (R.D.)

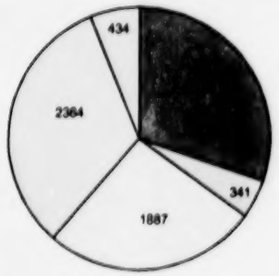
HIGHWOOD BASIN

OKOTOKS
River
TURNER VALLEY
BLACK DIAMOND
7
22
2A
SEE NOTE 1
M.D. 31
HIGH RIVER
23
Frank Lake
Sheep
LONGVIEW
River
I.D. 5
EDEN VALLEY FIRST NATION INDIAN RESERVE
HIGH WOOD BASIN
LITTLE BOW BASIN
Little Bow
2
Highwood
Mosquito
NANTON
Creek
River
COUNTY 2
M.D. 26
MOSQUITO
LITTLE BOW BASIN

HIGHWOOD



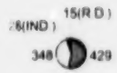
Current (1996)



Yr. 2021

Yr. 2046

LITTLE BOW



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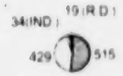
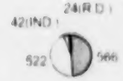
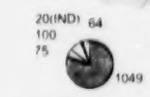


Yr. 2021

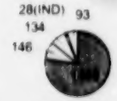


Yr. 2046



Current (1996)

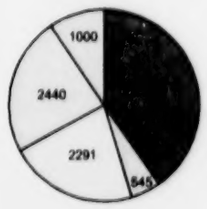
Yr. 2021



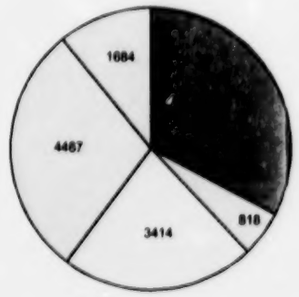
Yr. 2046

TOTAL STUDY AREA

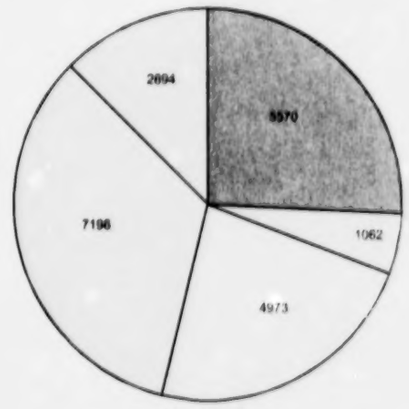
(shown 50% of actual size)



Current (1996)



Yr. 2021



Yr. 2046

NOTE:

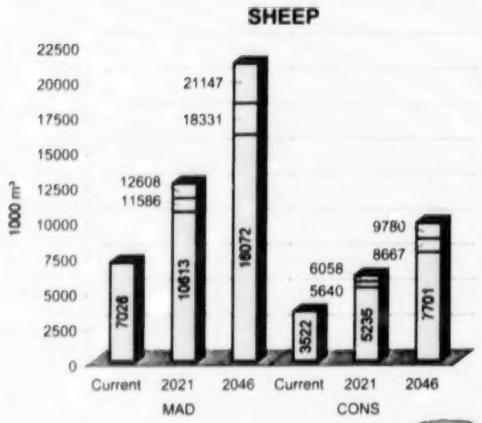
1. Flows to Frank Lake to come from the Town of High River, industrial plants and the Highwood River in 2021 and 2046 are not shown.
2. All values shown are in 1000 m^3 (dam^3).

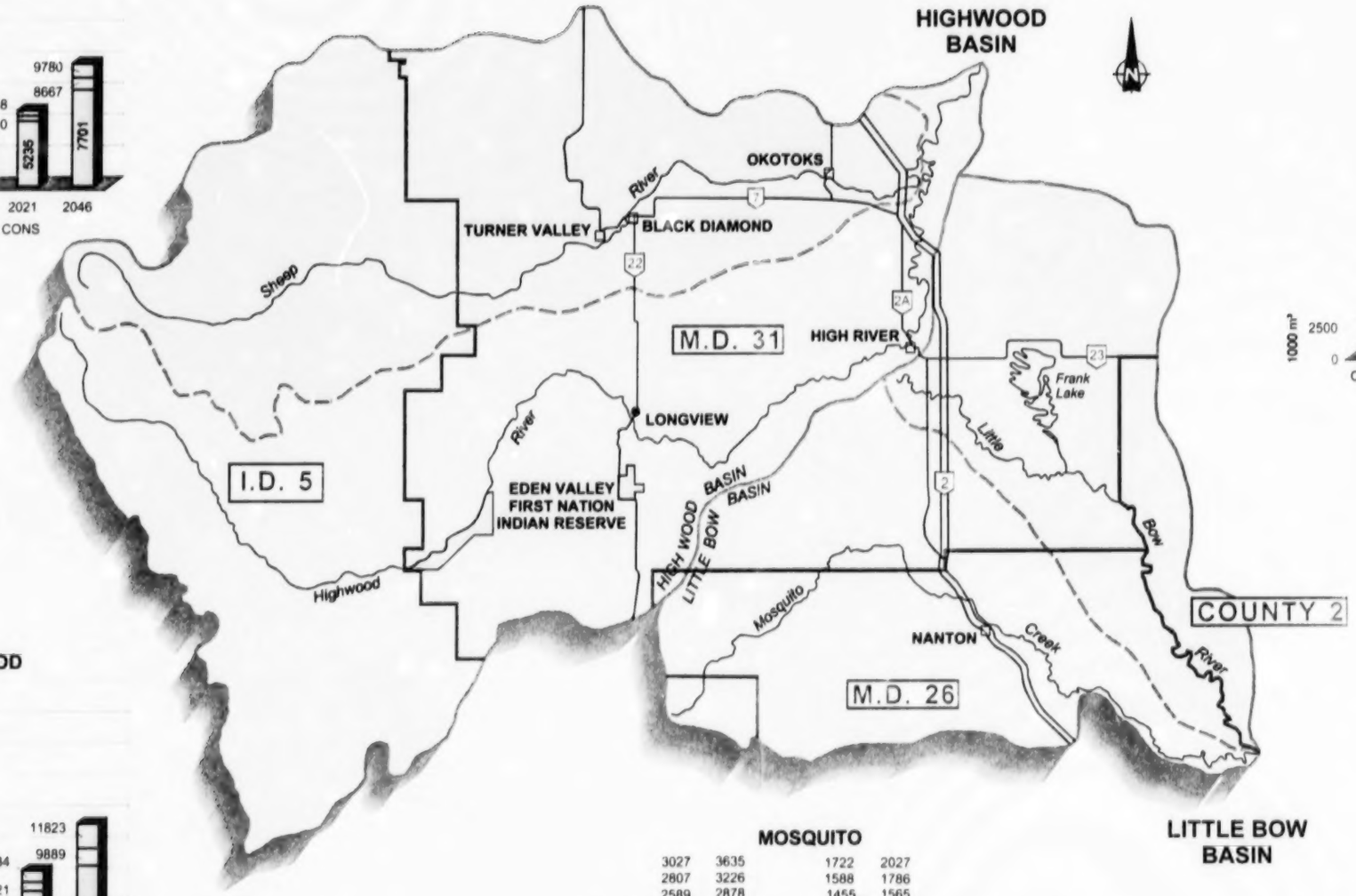
DRAWN: Gary Evenson	PREPARED BY: Hydroconsult; Worldwide Resource Economics
DESIGN: Paul Cox	PREPARED FOR: Alberta Environment
APP: Dave Cooper	
DATE: 99/03/12	
FILE: 371-A3 CDR	

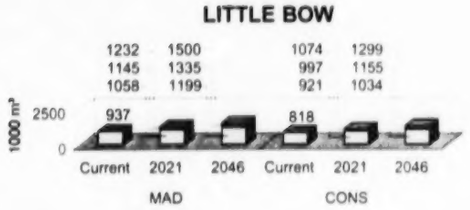
Non-Irrigation Consumptive Demand Projections
Little Bow Project EIA

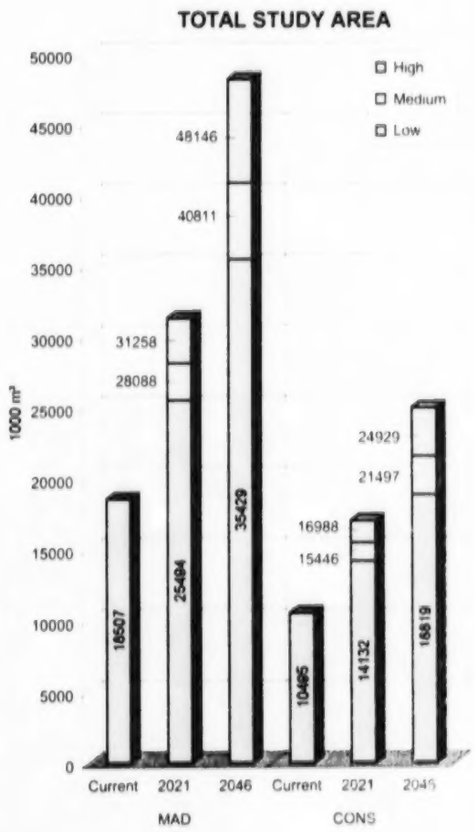
Low, Medium and High Withdrawal & Consumptive Use Projections

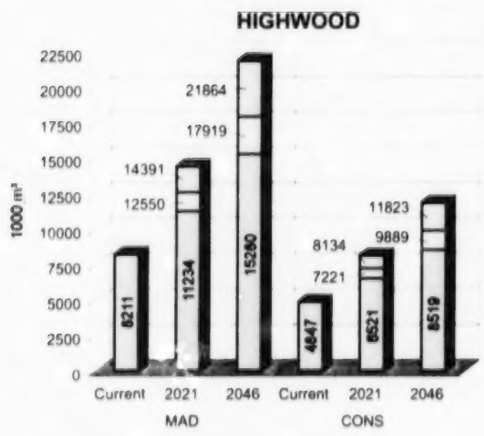
Figure 6

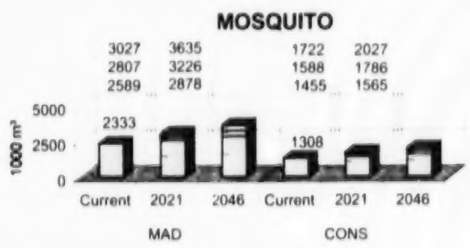












LITTLE BOW BASIN

DRAWN	Gary Evenson
DESIGN	Paul Cox
APP	Dave Cooper
DATE	99/03/12
FILE	371-A3 CDR

PREPARED BY: Hydroconsult; Worldwide Resource Economics

PREPARED FOR: Alberta Environment

NOTE:

1. All values shown are in 1000 m³ (dam³).
2. Flows to Frank Lake are not shown and are not included in totals.
3. Consumptive Use = CONS, Mean Annual Diversion = MAD.

APPENDIX A

TERMS OF REFERENCE

Little Bow Project Environmental Impact Assessment
Non-Irrigation Consumptive Demand Projections
Terms of Reference

1. **Purpose:** To develop projections for
   - population
   - water withdrawal and consumptive use for non-irrigation uses

   for the Highwood River Basin and the Upper Little Bow River Basin.

2. **Scope:**
   a. **Time Frame:** Three reference points will be used: 1997, 2022, and 2047.
   b. **Study Area:** Highwood River Basin and the Little Bow River Basin upstream of the proposed Little Bow River Reservoir.
   c. **Water Bodies to Focus On:** Highwood River, Sheep River, Mosquito Creek, Little Bow River
   d. **Jurisdictions to Focus On:**
      - MD of Foothills, MD of Willow Creek
      - County of Vulcan
      - Towns of Black Diamond, High River, Nanton, Okotoks, Turner Valley, and Vulcan
      - Village of Longview
      - Eden Valley First Nation

   e. **Water Availability Assumptions:**
      - There is a hydraulic connection between surface and ground water.
      - New allocations would probably be made if adequate storage is provided or if water rights transfers can be arranged.

   f. **Types of Activity:** Non-irrigation water uses include domestic, municipal (including water co-operatives), industrial, and agricultural uses (other than irrigation) that require a licence under the *Water Resources Act*. For uses with effluent discharge, estimate the loadings that would be generated.
   g. **Trends:** Social, economic, environmental, and water demand trends will be evaluated, but will only be accounted for in the projections if they are expected to have a significant influence on changes in either population or water use.
   h. **Analytical Methods:** It is expected that Year 2022 projections will utilize rigorous and well-accepted techniques for predicting population and water use. It is expected that Year 2047 projections will require less conventional, but equally defensible techniques. Sensitivity analysis will be conducted.
   i. **Deadline:** The project will be completed by February 15, 1999.

3. **Tasks**
   a. **Projections** Estimate population, agricultural, commercial, and industrial activity, and non-irrigation water use in the Study Area for
      - 1997
      - 2022
      - 2047.

   b. **Documentation:** All analysis and results will be fully documented.

Status of the Little Bow Project EIA

1. The Natural Resources Conservation Board (NRCB) has held hearings on the project.
2. The NRCB has, among other things, concluded that:

    a. Current water management in the Highwood, Little Bow and Mosquito Creek basins is unsustainable.
    b. Three components of the project (expanded Highwood diversion works, Little Bow River reservoir, Clear Lake diversion works and canal) are approved.
    c. The plans for operation of the three components during high flows are approved.
    d. Consideration of the operating plan during the low flow season of late July and August is deferred pending receipt and review of additional information.
    e. The revised operating plan should ensure that
        - the science-based instream flow needs are observed at all times in the Highwood River
        - existing licence commitments are upheld
        - adequate conveyance flows are maintained in both the upper Little Bow River and lower Mosquito Creek
        - known future demands can be met
        - consideration is given for reserving water, if possible, for future requirements that are unknown at this time.

APPENDIX B

PERSONS CONSULTED

APPENDIX B

PERSONS CONSULTED

Alberta Environment

Bob Morrison, Planner
Natural Resources Service, AEP, Calgary

Randy Poon, Engineer
Water Administration Branch, Natural Resources Service, AEP, Calgary

Tom Tang, Engineer
Operational Support Branch, Natural Resources Service, AEP, Calgary

Frank Lotz, Regional Engineer
Municipal Approvals Group/Water and Wastewater Branch, Environmental Service – Bow Region, AEP, Calgary

Sandra McDougall, Regional Engineer
Water and Wastewater Branch, Environmental Service – Bow Region, AEP, Calgary

Dave McGee, Regional Water Manager
Prairie Region, Natural Resources Service, AEP, Lethbridge

Brian Patterson, Water Administration Officer
Natural Resources Service, AEP, Lethbridge

Ian Franks, Water Administration Engineer
Natural Resources Service, AEP, Lethbridge

Kai Ma, Regional Inspector
Prairie Region, Water and Wastewater Branch, Environmental Service, AEP, Lethbridge

Dave Cable, Water Data Management Section
Water Sciences Branch, AEP, Edmonton

Other Government Departments

Lucette Dell'Oso
Statistics Canada, Ottawa (by telephone)

Owen Myhre
Statistics Canada, Calgary

Paula Brand, Land Development/Conservation Specialist
Prairie Farm Rehabilitation Agency, Calgary (by telephone)

Rod Bennett ,Head, Resource Conservation Section
Irrigation Branch, Alberta Agriculture, Food and Rural Development, Lethbridge (by telephone)

Glenn Werner, Director, Economic Services Division
Alberta Agriculture, Food and Rural Development, Edmonton (by telephone)

Reynold Jaipaul, Livestock Statistician
Alberta Agriculture, Food and Rural Development, Edmonton

Orin Kenzie, Intensive Livestock Siting Specialist
Alberta Agriculture, Food and Rural Development, Edmonton (by telephone)

Walter Valentini, Regional Manager
Calgary Region, Alberta Economic Development, Calgary

Fred Lee, Regional Construction Engineer
Southern Region, Alberta Transportation and Utilities, Calgary

Pamela Hunka, Demographer
Statistics Branch, Alberta Treasury (by telephone)

Vivian Ceilin, Health Assessment Facilitator
Headwaters Health Authority, Canmore (by telephone)

Doug Beck, Ph.D., Senior Corporate Economist
Finance Department – Corporate Economics Division, The City of Calgary

Dave Odynak, Research Analyst
Population Research Laboratory, Department of Sociology, University of Alberta, Edmonton

Municipalities in the Study Area

Richard Quail, (Infrastructure Services Manager)
Dave Robertson (Superintendent, Operations Branch) and Chris Fields (Economic Development Officer), Town of Okotoks

Gary Hudson, (Town Manager) and
Peter Sawicki (Director of Operational Services), Town of High River

Harry Riva Cambrin, (Municipal Manager) and
Bill Robinson (Municipal Treasurer), M.D. of Foothills No. 31

Lloyd Humphrey, (Village Foreman)
Village of Longview

Cindy Zabolotney, (Municipal Administrator
C.A.O.), M.D. of Willow Creek No. 26

Robert Strauss, (Count Administrator) and
Del Fischl (Assessment and Development Officer), County of Vulcan No. 2 and
Scott Kovatch (Economic Development Officer), Vulcan County Economic Development Office

Wally Sholdice, (Municipal Administrator)
Town of Vulcan

Karen Harty, (Municipal Administrator) and
Jim McMaster (Public Works Foreman), Town of Nanton (Jim McMaster by telephone)

Rob Strom, (Municipal Manager/Director of Operations)
Town of Turner Valley

Doug Christensen, (Public Works Supervisor) and
Linda Henrickson (Planning & Economic Development Officer), Town of Black Diamond

Roger Watamanuk, (Band Administrator) and
Heather Colosimo (Nurse-in-Charge, Health Centre) and
Peter Palaj (consulting engineer) and
Clifford Jimmy John (Water System Maintenance), Eden Valley First Nation (all individuals by telephone)

Other

Gerry Brunen (District Manager) and Dave Anderson
Ducks Unlimited, Strathmore

APPENDIX C

BIBLIOGRAPHY

APPENDIX C

BIBLIOGRAPHY

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